Experimental Note - Book

Vol. ~~VII~~

Alexander Graham Bell

November 25th 1878

N. J. S
Jan. 20, 1879

Thought Nov. 25th 1878

Hydro-electrometer

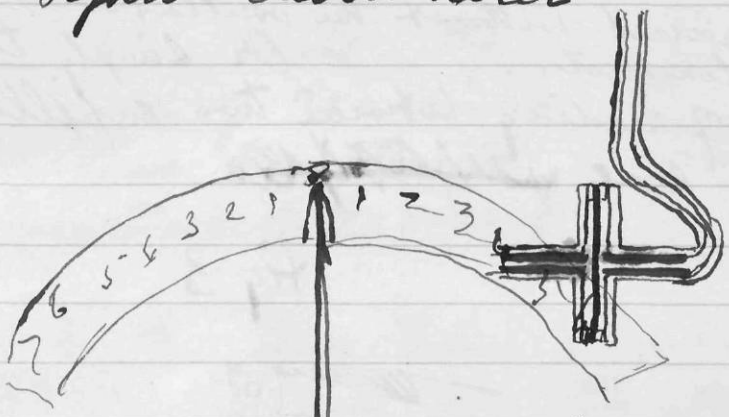
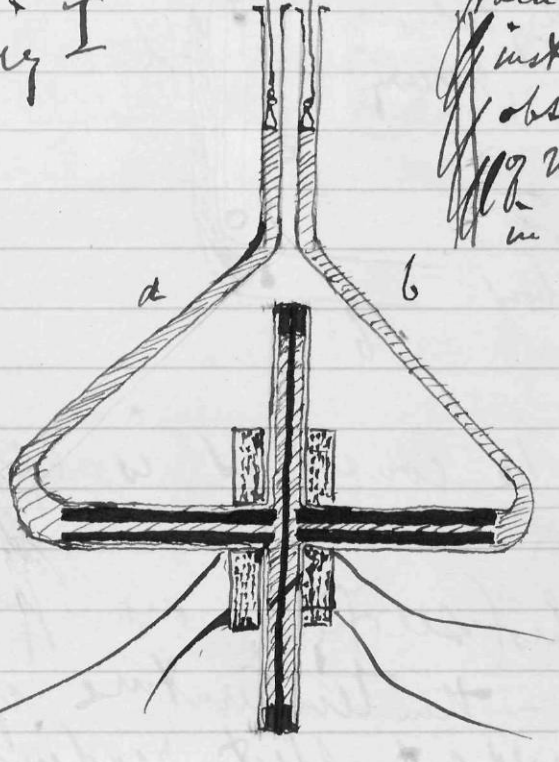


Fig I

If weight of water too great then lay pipes a b horizontally instead of vertically and observe the motion of a globule of mercury or marker as in Fig 2.



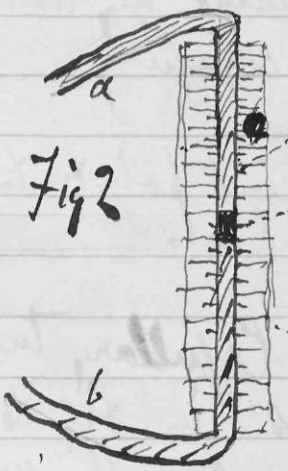
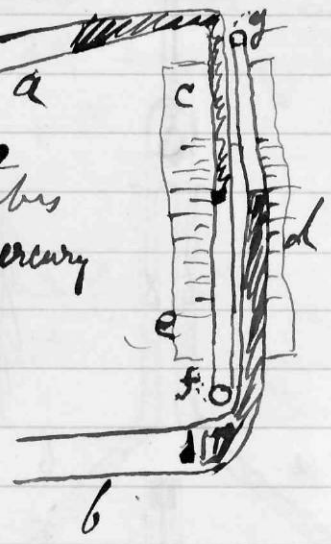


Fig 2

a } same pipes
b } as in Fig 1
c Horizontal Capillary tube
d marker
e scale

Gain greater delicacy by causing the liquid to turne a mirror. It is probable that a deflection would immediately be gained without the oscillations of the ordinary galvanometer. Or simply take the difference of reading between two capillary tubes side by side.

Fig 3



Pipes a & b as before
c & d capillary tubes containing mercury
e — scale
The ends f & g may be turned vertically upwards so as to prevent any likelihood of mercury escaping.

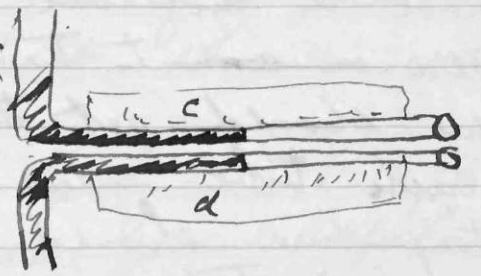
Special point to be considered is effect of temperature.

If Capillary tubes (see Fig 3) are placed parallel as in Fig 4 — then temperature affecting both tubes equally would not affect reading

R. J. S
Jan. 20, 1879

In Fig 4 the height of the zero would give the temperature and the difference of readings would give the strength and directions of the current.

Fig 4



In Fig 3 the two tubes should ~~give~~ the same reading for the strength and direction of current — and any difference of reading would give the temperature. The strength and direction of current could always be told by taking the mean of the two readings always supposing the two tubes to be equally heated. In Fig 3 the displacements in the two tubes due to the movement of the plate should be equal and opposite so that the amount of movement ~~in each tube~~ should be the same in both. Whatever then be the temperatures of the tubes the difference of reading should be uniform ~~in both tubes~~. Take the difference of reading before passing the current and the difference while it is passing — the difference should be the same unless the temperature has changed ~~between~~

the two readings. ~~The readings~~ If we then have a moveable scale (as in fig 5) and adjust the zero ~~on each~~ to the mercury on each side we should get the same reading from each tube unless they ~~differ~~ in bore or unless temperature should change while the readings are being taken.

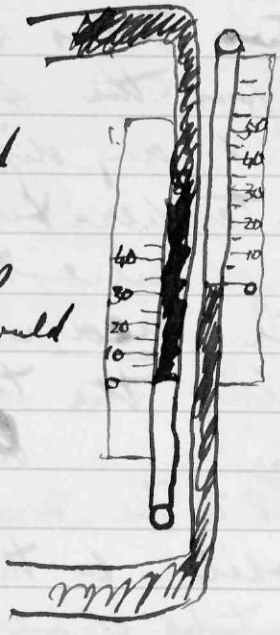


Fig 5

Although reading of only one tube would be enough still the mean of the readings of the two tubes would give more accurate result

It has often occurred to me that if one form of vibration can be transmitted ~~and~~ produced electrically why not another? If sound why not heat? I remember that W. Watson & I heated telephone plates and sought to find a rise of temperature

R. F. S
Jan. 20, 1879

in the plate of a distant telephone without any result. If any rise of temperature takes place the instrument shown in Fig 5 should indicate it.

Noted by A.G.B. November 25th 1878
at the Mass. General Hospital

November 29th 1878

Phonographic ideas. Continuous strip of paper or other material seems to me the most feasible plan. Make a groove of uniform depths or a ridge of uniform height with the vibrations impressed horizontally instead of vertically — would form splendid field for experiment. Such a line could be made to control vibration of ~~receiving~~ the repeating phonographs in every place.

Fig 6

Another plan — Make the strip of paper vary in thickness. No — this would only control the vibration when going from thin to thick — not necessarily when going from thick to thin.

Keeping the paper of uniform thickness cause the central portion of the strip to be indented or embossed according to the vibrations of the plate — and have guide lines or ridges on the paper to keep the paper in position.

Guide lines C D and E F
A B — indented central portion.

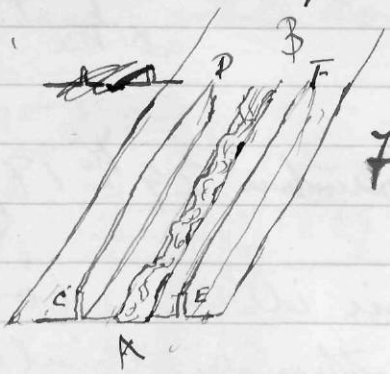


Fig 7

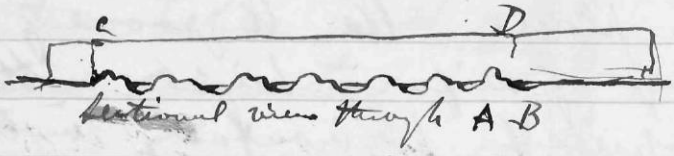


Fig 8

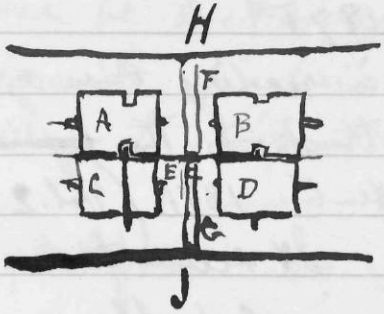
Sectional view through A B

Make the guide lines by passing the strip of paper between two rollers one having a ridge upon it and the other a groove into which it fits. Thus there would be four rollers

A. G. S.
Jan. 20. 1879

Sectional view

Fig 9.



A B Rollers with grooves
C D Rollers with ridge
E edge view of strip of paper
F G Runches attached to
H J Phonographic diaphragms.

Fig 10

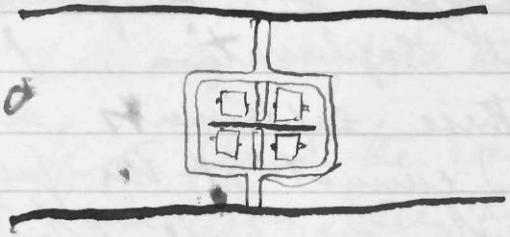
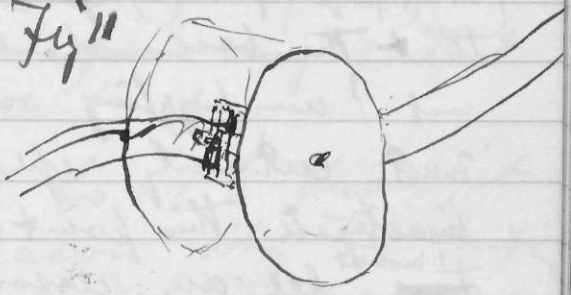


Fig 11



Dated November 29th 1878
AGB

4

Saturday November 30th. 1878

I have been much interested in reading over my old note-books and I am specially struck by the ~~experiments~~ thoughts noted on the 14th. of September 1876 (Vol. 2 page 51) and subsequent experiments. It seems to me that the principle involved ~~in them~~ is capable of very valuable applications. I am particularly struck with the unexpected discovery made Sept. 29th. 1876 (noted page 89 Vol 2) ~~that~~ that it is absolutely necessary that the base should ~~be fixed~~ not be fixed — and I am puzzling over the explanation. I must certainly repeat these experiments and investigate this point. I cannot at the present ~~moment~~ moment see any reason why the base should be free to vibrate. It seems to me that a vibrator actuated on this principle might be ~~combined into some~~ utilized in some form of Electro-motor for the vibrations are very violent.

Why should not Microphone idea ~~come into~~ be utilized. Let vibrating armature carry a small piece of carbon ~~to~~ and the pressure between it and neighbouring surface would vary directly as the velocity of movement and the

M. F. S.
Jan. 20, 1879

armature be sustained in vibration without break of circuit producing an undulatory current corresponding to vibration of reed.

In simplest form so — Fig 17

a piece of carbon wedged in between b + c.
d. a wire connected with carbon
c. vibratory armature of magnet f

The carbon a is to be insulated so that it shall only complete the circuit at b.

If we pluck the reed e so as to throw it into vibration I see no reason why the vibration should not be sustained — for the pressure of a against b should vary with the velocity of the motion of e. Of course a could be so loosely arranged as to cause an actual break of circuit at b if desired. Possibly a certain adjustment of a would found to give best result for each reed.

(Thought) Inverse Induction of current upon itself in the coils of an electro-magnet can perhaps be overcome or partially neutralized — & when vibratory armatures are employed

if the circuit is never broken.

When primary current is increasing in intensity secondary currents tend to weaken it — and vice-versa.

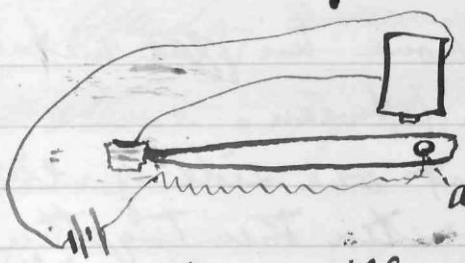
Now the vibration of ~~the armature~~ an armature in front of excited electro-magnet induces a current in one direction ~~when~~ approaching and in opposite direction when receding.

~~Now if the is~~ Now in apparatus shown in Fig 12 — if apparatus can be so arranged that the current induced in the magnet (F) by the approach of the armature (e) shall traverse the coils in the ~~opposite~~ same direction with the voltaic current — then the magneto-induced current will be opposed to the voltaic induced current (that is the secondary current induced in the coils by the passage of the voltaic current) and easily some form of apparatus could be constructed whereby one should just neutralize the other leaving the primary current entirely undisturbed by secondary induction.

Other forms in which ~~electric~~ intermittent or undulatory currents could be obtained.

N. Y. S.
Jan. 20, 1879

Fig 13

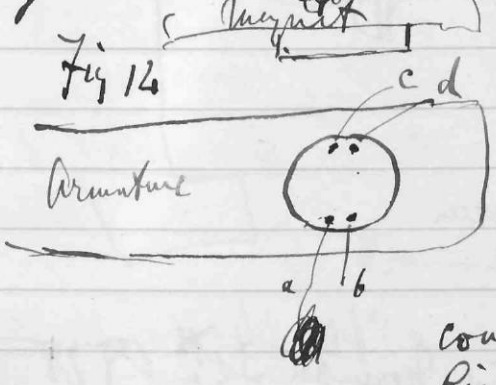


(Intermittent)

Make a hole or rather "hollow" in armature a and place into it a drop of mercury which will be thrown from side to side as the reed vibrates. Introduce ~~d~~ into the side (d) of the hole furthest from the magnet the end of a wire which must be insulated from the reed. ~~and and make contact when the~~ as the reed approaches the magnet the mercury will be thrown against the point (a) and ~~complete contact between the wire~~ will thus complete the circuit.

The hole or rather "hollow" idea seems to me good. Modifications of it.

Fig 14



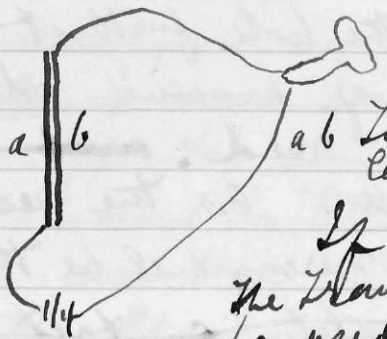
In Fig 14 drop of mercury or pin of carbon completes contact between terminations of wires a b.

Other contact points could be made at cd if desired which could communicate either with main Line & battery or with magnet or other side of reed. A little metallic ball would answer in place of mercury or carbon.

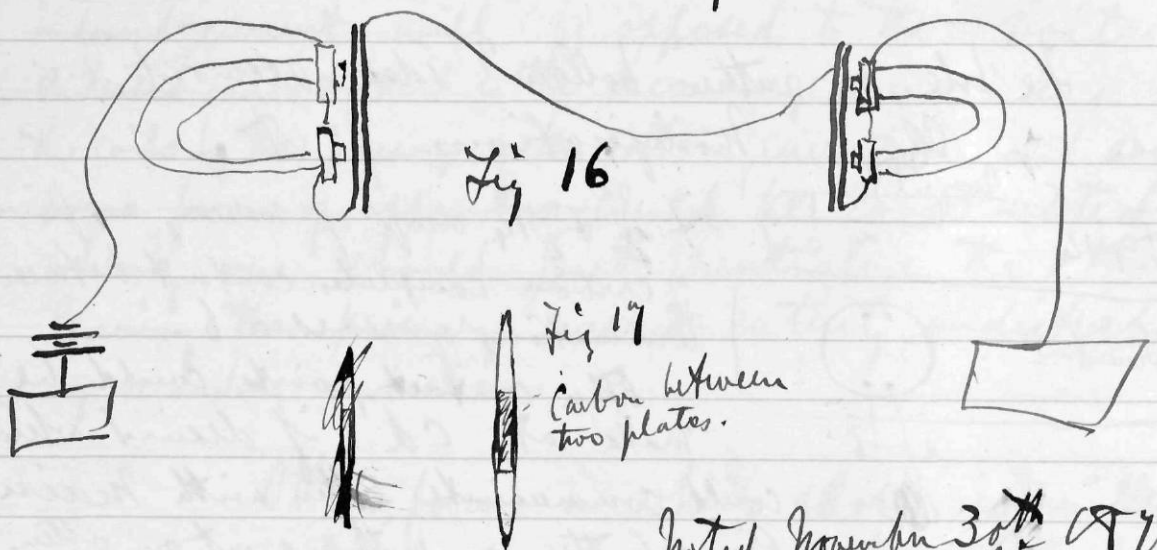
Try as one form of Microphone two ~~[illegible]~~ metallic plates with a carbon film between.

Take two iron plates. Coat one side of each with Lamp-black and fasten them together with the Lamp-black surfaces touching. See Fig 15

Fig 15



If this succeeds - then the Transmitter could also be used as a Receiver as in Fig 16



Noted November 30th 1878

N. J. S.
Jan. 20, 1879

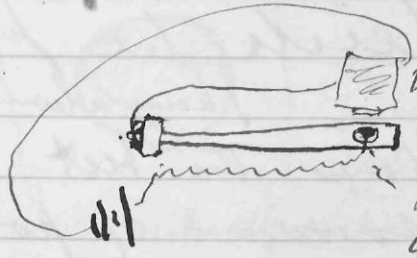
Sunday morning December 1st 1878

Idea shown in Fig 18 (page 11) can be varied as follows :—

Fig 18

(a) – a pencil of carbon or plumbago insulated from the edge of the hollow (d) and connected with insulated wire (b). The plumbago projects into mercury (c) which does not quite fill the hollow (d). A cover may be fitted over the hollow (d) so as to prevent the mercury from being spilled and the hollow itself may be completely filled with glycerine or alcohol to preserve the mercury from contact with the air and thus prevent oxidization.

Fig 19



Magnet single or double pole vibratory armature

Hollow containing mercury and carbon as shown in Fig 18 in detail

Thought. Could it be possible to form a vibratory battery. Vibration would probably serve the same purpose as the air in Bygnes' Pneumatic Battery.

The only function of the air seems to be to agitate the liquid and prevent the formation of a layer of gas on the plates and thus prevent depolarization. Vibration would do the same.

A very intense current could thus be produced and at the same time the internal resistance of the battery being varied in proportion to the velocity of the motion an undulatory current would be produced.

Perhaps a plate could carry a microscopic battery and articulate speech be produced in this way.

I have always believed that in Battery Telephones the best way is to vary the current at the source of power and vary the it rather than the external resistance — and in my patent filed Feb. 14th-/76

N. J. S.
Jan. 20, 1879

I have claimed this as one method of doing so. I have often sought to discover some practical method of accomplishing this and it seems to me that the above idea can be worked up into something practical. Perhaps the simplest way of experimenting at first will be to adopt the experiment shown in Figs 18 and 19 (Fig 13) but substitute for the mercury — dilute sulphuric acid. The arrangement then becomes a battery — the two elements being iron and carbon. Of course platinum would be substituted for the carbon — or and the hole lined with amalgamated zinc. Of course no other battery to be included in circuit.

A few ideas to try

Fig 20

Arrangement on circuit. (a) is the vibrator battery.

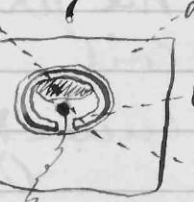
Fig 21

a iron or steel reed one element of battery

dilute sulphuric or other liquid suitable for battery

platinum or carbon pencil to be placed vertically or horizontally as in Fig 18.

Fig 22



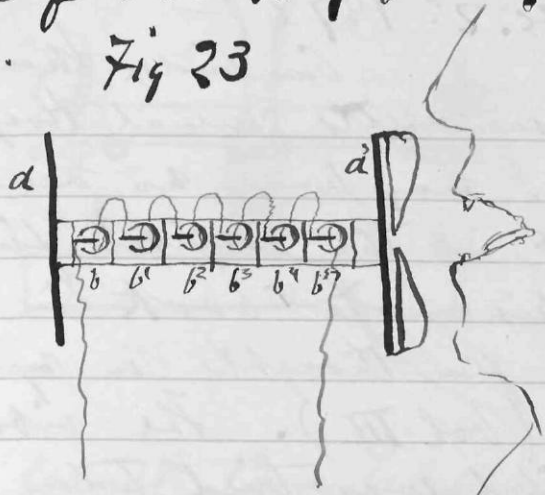
a — reed.
b — analg. zinc
c — platinum
d — battery fluid.

If the reed armature were made very large it might carry a number of minute cells which could be arranged in series or in multiple arc as desired. It would not take any very great power in the magnet to sustain the whole in powerful vibration — as the increase and diminution in the attractive power of the magnet would be timed to the normal oscillations of the reed. — ~~and the vibration~~ The reed would ~~probably~~ not start itself — but once started mechanically I see no reason why it should not be sustained in very powerful vibration. The current might be utilized in various ways. ~~It might either~~ For instance pass it through the primary wires of an Induction coil and utilize the secondary current for external purpose.

Or one of the cells carried by the reed could be used as a local battery to sustain the vibration of the whole and the other cells be used for other purposes.

N. J. S. Jan. 20. 1879

A plan of vibratory battery for the human voice. Fig 23



a a - Telephonic diaphragms of a suitable material. Probably metallic best.

b b' b² b³ b⁴ b⁵ - Minute battery cells ~~[illegible]~~ supported upon a piece of wood or other suitable material & the diaphragms (a a') and attached at each extremity to the centre of one of the diaphragms.

The voltaic elements I should first try would be as illustrated below in Fig 24.

Fig 24

(b) Take Bagnis Pneumatic battery as my model. Arrowheads show direction of vibration ~~[illegible]~~ Copper coated with lead ~~[illegible]~~ piece of platinized platinum foil. (c) zinc (d) d - Bichromate of the wedge in contact with liquid surface. The concave solution containing slight excess of chromic acid. (a) glass or other non-conductor forming the cell.

Noted Sunday December 15th 1878

A. M. Bell G. B. Hubbard Alex. Graham Bell Mabel Gardiner Hubbard

Monday Dec. 2d 1878 —

Cambridge Mass —

I left the Massachusetts General Hospital today and I hope I may have no need to return. Last night at the hospital finding that I had left this note-book in Cambridge I ~~made a~~ noted a few thoughts in my old Experimental Book (Vol III). The vibratory battery there described was tried today.

Twelve disks of thin copper and twelve disks of thin zinc were taken — each disk one inch in diameter — and about 1/16 inch in thickness I should think. Twelve disks of woollen cloth each at least 1/8 inch in thickness were moistened in dilute sulphuric acid and interposed between the copper & zinc disks so as to make a voltaic pile as shown in Fig 25

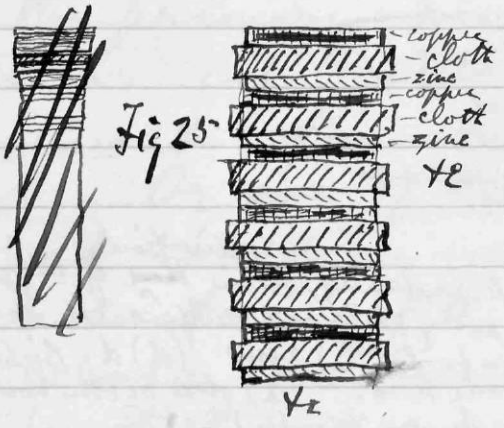


Fig 25

This pile was subjected to slight compression from a telephone plate as shown in Fig 26. Dimensions of plate — 4 inches diam. and about 1/16 inch thick — the ordinary russia iron plate used

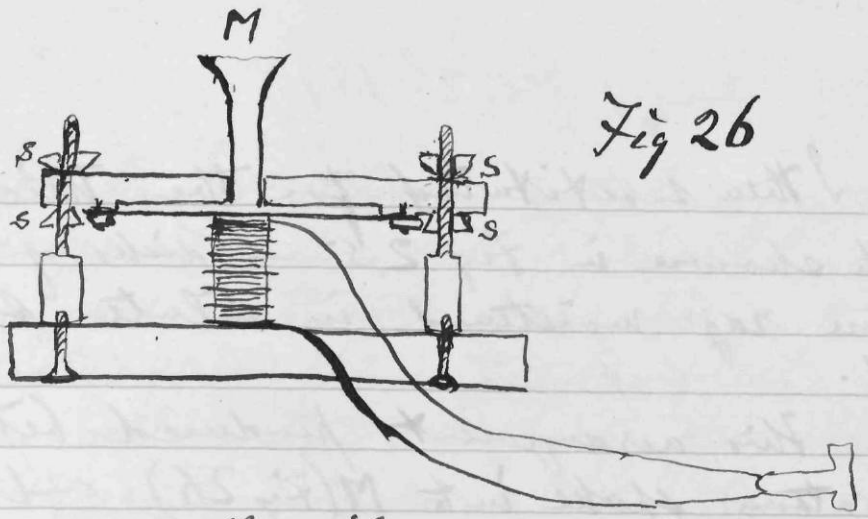


Fig 26

in the largest Box Telephones.

Quite a powerful current was produced by the pile — When the circuit in which it was placed was broken a loud click was audible from the Telephone T.

The apparatus as shown ~~today~~ in Fig 26 was tried today at Mr Williams' Office. Edward Wilson spoke into the mouthpiece M while I listened at the Telephone T which was placed in another room.

Result — Voice audible faintly from T. Could understand a few sentences.

Tried varying the pressure by moving the screws SSSS — Voice perfectly audible but pressure did not seem to make much difference in result.

I then substituted for the thick woollen cloth shown in Fig 25 — discs of thin cotton rag moistened in dilute sulphuric acid.

This arrangement produced better results. Mr Watson spoke into M (Fig 26) and I listened at T. Articulation at first faint but upon raising the diaphragm until the pile had scarcely any pressure upon it — the voice came out very loudly occasionally — and then sank down again. As the diaphragm was raised a point was reached of loud clear articulation then an intermittent current was produced.

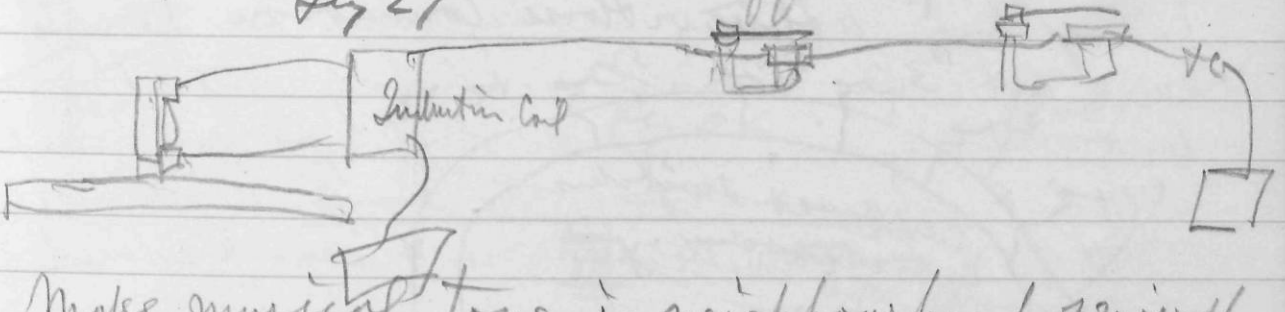
The results are encouraging and we must try experiment again with more carefully prepared apparatus so that all the parts may be adjustable. The plate too should not be so rigid as that tried. Try carbon and zinc and get microphonic effect in addition to battery effect. Vary the number of elements in the battery. Probably one or two pairs will give maximum effect. Also try induction coil.

N. F. S.
Jan. 20, 1879

Bell Telephone evidently want some call arrangement so as to call up certain houses without disturbing others. Musical note principle is the simplest.

Have bells with vibratory armatures tuned to different pitches. Call up either by means of Rheotomes or by a Microphone arrangement at central office.

Fig 27

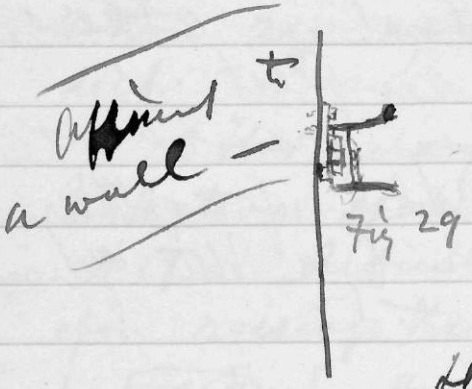


Make musical tone in neighbourhood of microphone and ~~Receiver~~ Receiver tuned to that pitch will vibrate ringing bell.

How about houses calling central office or calling one another?

Dec. 25th 1878

Hotel & House Telephones with battery.



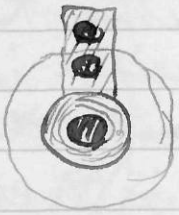


Fig 28

Hotel or House Connexions

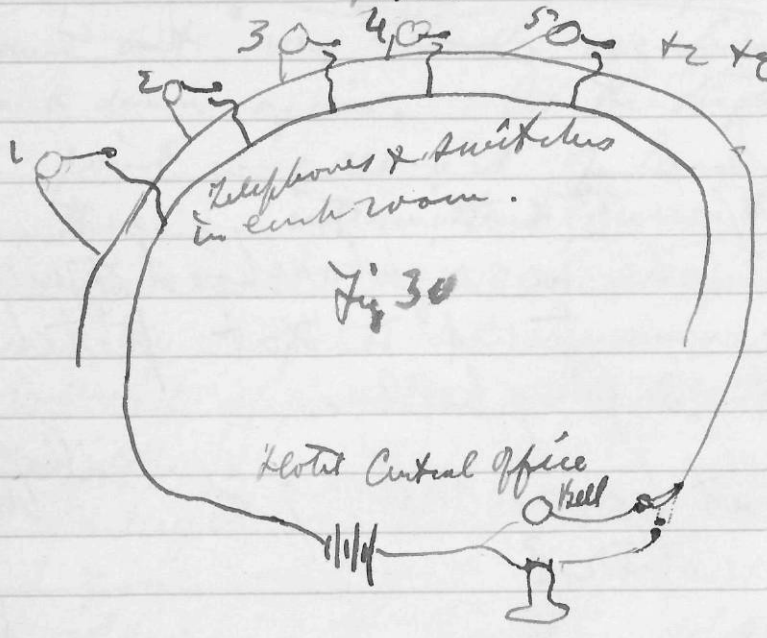


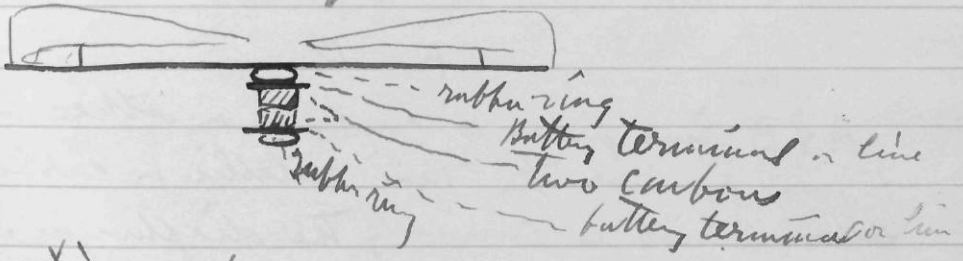
Fig 30

A. G. S.
Jan. 20. 1879

Combine Q carbon with Vacuum

Fig 31

Fig 32



Connections as above

Noted Jan. 25th 1878

AGB

Dec. 30th 1870 —

by Frictional Carbon Telephone. Resistance will probably change during motion (rubbing motion) of carbon and thus a current be produced strictly proportional to the motion —

by following plan.

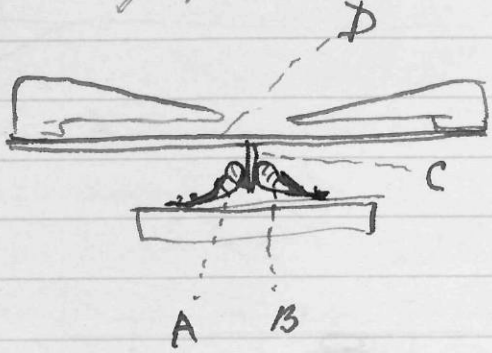


Fig 33

A + B Two pieces of carbon or other material caused to press against the thin metallic or carbon slip C ~~attached~~ which is carried by the diaphragm.

Fig 34

Notes Dec. 30th 1870

A.G.B.

1879

Wednesday Jan 1st 1879

Baby celebrated the New Year by cutting a new tooth. She now has two on the lower jaw — one on the upper — and a swelling indicating the presence of another tooth on the upper jaw at no distant date. These teeth are all incisors. Elsie is changing fast into a little girl. She has already half lost — the small-baby look — and seems now to have reached the age for observation and experiment.

She observes every one's motions — tries to test ~~everything~~ the reality of objects by the sense of touch. Tests their solidity with her newly acquired teeth. Exhibits a perception of grasping distance. Does not hold out her hands for things until they are near enough to grasp. She tests her voice in all sorts of ways — and when she is happy "squeals" in the funniest manner. By random motions of her mouth she occasionally strikes English & foreign sounds, but evidently with no intention. I have noticed the following vowels & consonants

] l [TT] ∂, 3|3|3|, ∂|∂|∂|∂ 3

C and C♯ The last produced by disgust for her medecine.

These sounds seem to be produced for the most part accidentally but within the last three days she has taken to imitating her nurse when she says ∂|∂|∂|. Mabel thinks she has said "Mamma" — but I doubt this, and of course Mabel cannot judge of the difference between ∂|∂| and ∂|∂|.

I often overhear a little conversation like this between nurse & baby

Nurse — "Now baby say "Mama — Mama Mama Mama"

Baby ∂|∂|∂|∂|∂|

Nurse — "Now say "Papa Papa Papa"

Baby ∂|∂|∂|∂|

Sometimes the response is 3|3|3|3| instead of ∂|∂|∂|.

I have not yet heard either the word "Papa" or "Mama" nor even a dis-syllabic ∂|∂|. Nurse thinks she has said "Mama" but I very much doubt it — as approximations are very apt to be taken for words when the judgement is biassed

Ch. J. S.
Jan. 20. 1879

in the proper direction.

Elsie will be eight months old in one week. In appearance she is now a really lovely child — inclined to laugh and smile at every one — and to pull hair! I have to imprison the little fingers when my whiskers come within grasping distance. At birth Elsie was as dark as a red indian and altogether unprepossessing in appearance — a decidedly plain child. How she has changed all that. She is quite fair compared to her former complexion — and has wonderfully large lustrous eyes — that strike a stranger at once. She is now not merely a nice looking baby — but is really a very lovely child. When we brought her across the Atlantic she was the pet of all the lady passengers and also of several of the gentlemen. We left Liverpool on the 31st. of October 1878 in the steamship Sardinian for Quebec — and made the fastest voyage on record. The Lord Bishop of Niagara took a great deal of notice of Elsie and seemed to delight in patting her cheek saying "Nice baby — Nice baby". The Hon. Edward Blake of Canada was so fond of her that he would

take her in his arms and trot up and down the saloon with her many times every day.

Baby seemed quite happy with him - staring up quite contentedly at his spectacles - or looking round on the passengers. The washing of baby in the ~~Cabin~~ Ladies' Cabin seemed to be the feature of attraction to all the ladies on board - for whenever I ventured to look in upon Mabel at such times - I found her performing on baby in the presence of an excited and enthusiastic audience of ladies and the words "Isn't she lovely!" - "What a duck of a baby" - "How good she is" - and other expressions of a similar character - ~~all~~ seemed always to be floating about the room in a subdued murmur.

From Quebec we went directly to Toronto where my father met us. My father took Mabel, Elsie & her nurse Annie, and Miss Horne on to Brantford while Mr Watson & I stayed behind to see the Hon. George Brown. I followed by the next train but was quite crippled by two abscesses that had been troubling me on the voyage over.

In Brantford I had one of the abscesses lanced and proceeded next morning to Boston with Mr Watson - leaving Mabel & Elsie behind with my father and mother.

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On arriving in Boston the unlanced abscess was so much worse that I went to the Massachusetts General Hospital — to one of the private rooms — where I was confined for three weeks. After being in hospital for about a week — Mr Hubbard went up to Brantford and brought Mabel Elsie & Nurse to me in Boston. ~~Mr~~ They stayed in Cambridge at Miss Blatchford's house and Mary came into Boston every day to see me. Occasionally also — Elsie would be brought to see me. In Kensington I was not quite satisfied with the way Elsie was dressed. I don't know what the matter was — but I fancied she did not seem to be dressed as nicely as other respectable babies (in Boston) The first day I got out of the hospital, I entered a horse car to go out to Cambridge — and noticed a baby in the car who seemed so nicely dressed — ~~that~~ and was ~~so~~ so pretty and attractive — that the thought involuntarily arose that I wished Elsie could be like her. Upon entering the car I felt quite proud to find it was our own baby after all.

She smiled at me and held out her hands and I really felt gratified that the passengers should see that I was the father of such a sweet lovable little child.

Elsie caught cold in coming down from Canada — and Annie noticed one morning a little appearance of moisture in her right ear. She did not say anything about it however at the time. Three days afterwards I happened to have summoned Dr Putnam to see Mabel as she was not very well and her supply of nourishment for baby seemed to be failing — and discovered from him that nurse had observed for the past three days an appearance like moist wax in the right ear. Annie (the nurse) had told Miss Blatchford that morning and she had told Dr Putnam. I immediately consulted Dr Blake who came out and examined baby's ear. He stated that there had been inflamation in the middle ear and that the membrane was already perforated. There had been discharge through the perforation and the aperture seemed then to be healing up. Baby's hearing did not seem to be affected — but the fact that the

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first attacks could she has had should have flown to her ears has alarmed me exceedingly and has made me determine to fix upon her extirpation at as early an age as possible — in case of any accident ~~befalling~~ to her hearing.

Dr. Blake examined her ears again before we left Cambridge for New York — and pronounced the restoration of the membrane complete. In New York we staid for a day or two at Wm. McCready's house. ~~He was~~ Wm. McCready seemed much pleased with his little Grent — grand-daughter. ~~Mr. Charles Marsh~~ Mrs. H. Marsh (Aunt Kittie) and Mrs. Charles Marsh (Aunt Bertha) both have babies and the experiment was made to see whether the respective babies would partake of nourishment from others besides their own proper Mamas. They seemed quite indifferent to the sources of their food supplies — and partook quite freely of nourishment from Nature's fountain — whenever & by whom presented. ~~Elsie~~

Elsie — I understand — ɑʊʃɛʊɾ ɜʃɣ ɘʃɣ ʃʊʊʃ ɑʃʊʃ (!!) ɔɾʊ ɘɾʃʊɾɘ ɘʃɣɾ ɔɾʊʊɾ ɪɔʃɾ

Gertrude came on with us to Washington — but

Berta was obliged to remain in New York to submit to certain painful dental operations, which have become necessary. Elsie's cold seems to have been rather aggravated than otherwise by her change of climate, and the poor little thing coughs so badly and in such a strangulatory sorting way that we half suspect she is either recovering from or making headway for — Whooping Cough. The cough has lasted so long that we feel quite anxious about her. Otherwise however she seems as well as can be expected from a child who is teething. We removed into our present house — No 1509 Rhode Island Avenue - Washington — on the 23rd of December. My father & mother who had been on a visit to Mrs Lander — joined us here on ~~Christmas day~~ the 24th — and on Christmas Day — Mr & Mrs Hubbard Gertrude & Grace and my father & mother dined with us in our own house.

Mabel & I had one at cross — purposes in our shopping for two turkeys made them

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appearance and two separate supplies of ice-cream. The baby was duly congratulated by all and sundry — and was presented with various toys by her grandfathers & grandmamma — and by her Papa & Mamma. The thing that takes her fancy most is a set of jingling bells. She delights in shaking these about and making as much noise as possible.

When I came to Washington I employed for baby the surgeon who attended me some years ago when I sprained my ankle (Dr. Garnett). He is an elderly man — and is evidently more of a surgeon than a baby doctor. After seeing him prescribe for baby — I did not feel any confidence in him as a doctor for a delicate little organism like that of a baby. Mabel & Mr. Hubbard & Gertrude & all seemed to agree with me in my lack of confidence. We felt that he was the sort of man who could cut off a man's leg well & creditably — but we did not feel we could trust our baby to him. When we discovered in a prescription he had written for baby — that a large quantity of calomel was to be given to her — I informed

him politely that we intended to employ another doctor for Elsie — and we have now engaged Dr. W.W. Johnson who seems to possess the confidence of the mothers of Washington.

Elsie seems much better. Her cough is far less troublesome than a day or two ago, and I hope in a few days she may be able to go out and ride in a new four-wheeled perambulator I bought for her in New York.

Mabel & I have learned to love baby very much and she becomes every day more attractive — more "cunning" — and more loveable.

Written January 1st 1879

AGB

N. J. S.
Jan. 20, 1879

Jan. 1st 1879. Frictional idea grows.

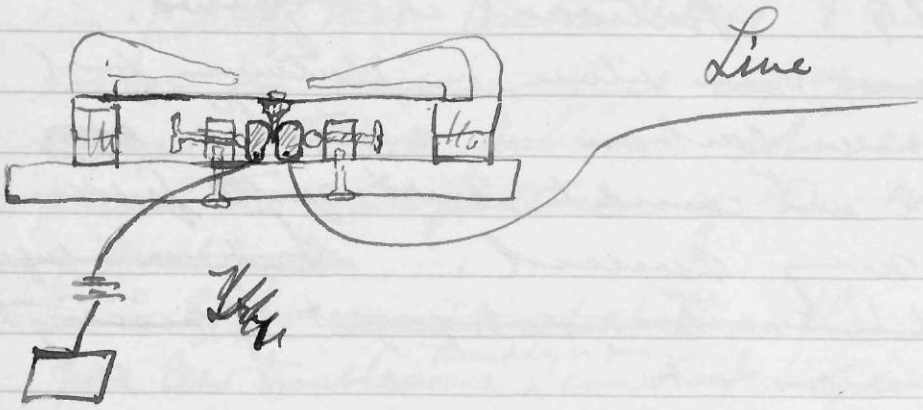
Perhaps brass, german silver, or platinum foil vibrated between carbon or metallic ~~[illegible]~~ masses which are caused to exert gentle pressure upon it may succeed. ~~Surely an imperfect contact would be made more imperfect by moving the two~~ points in contact

Given two surfaces in contact offering a certain amount of resistance. ~~[illegible]~~ Now slide one surface over the other. Surely the resistance must be affected (either increased or diminished) and if so — it should be affected in a greater or less degree as the velocity of the sliding motion is increased or diminished.

~~[illegible]~~ If the resistance is affected at all by the motion ~~[illegible]~~ I see no reason why it should not be affected proportionally to the motion. Hence if we create the motion by a sound — an undulatory effect should be produced in the electrical current.

Shall try following arrangement this afternoon or evening ~~[illegible]~~ see over

Fig 35-



W. Maynard made an experiment for me on either Monday or Tuesday night — to ascertain whether a ~~number of~~ single magneto call-bell could be used for a number of telephone lines at the central office.

A five lines were united at W. Maynard's office as shown in Fig 36 — and the attempt was made to ascertain whether a person on one of the lines could ring up the central office without ringing the bells on ~~the~~ the other circuits.

I rang my bell on line 3 and not only did the central office bell ring — but also ~~the~~ a bell on line 1 at A — An observer stationed at B (the fourth house on Line 2) did not hear his bell ring under those circumstances — but

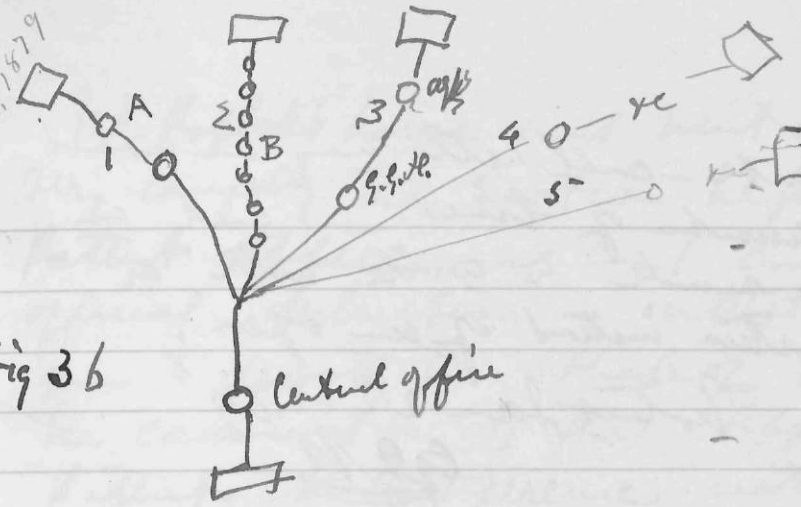


Fig 36

another observer on one of the lines 4 or 5 heard his bell ring feebly.

Mr A on line 1 — gave signals which affected central office bell — & also rang my bell on circuit 3 but feebly.

Mr B. on line 2 was unable to affect bell of Mr A on line 1 — nor my bell on line 3 — I could hear his bell ringing however the moment I placed my telephones in circuit instead of the bell.

In every case the central office bell rang much more feebly than when it was in circuit with only one of the lines.

It seems probable that by reducing the resistance of the central office arrangements to a minimum — & by inserting in each subscriber's line a considerable resistance — that

a single magneto-call bell may be used for a large number of lines — and an indicator may be made to work with a closed circuit system instead of an open.

Patent Jan 2d 1879

Jan. 2d 1879 Wrote this morning to Eldridge of Chicago — offering assistance in Telephone Record. Also wrote to Mr Devonshire, Telephone Co Limited, Fitch Fox & Cutler, Crosby & Gregory, C. E. Hubbard Gallaudet, Rey. Baird, Dr. Hunter, Dr. Gillett Noyes, Prof Fay, & Prof Hyatt. Dictated to Miss Sumner abstract to first draft of a Caveat for the new art of transmitting telegraphic signals & articulate sounds to a distance by means of light.

Put my battery of ten cells of Gravity Battery in order. Made a cable of six wires twisted together ala my Induction Patent — for the purpose of demonstrating the value the method. Cable about 50 feet long. Also constructed a portion of frictional telephone shown in Fig 35. This evening went to

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Mr. Pollok's house and went over with him very carefully the motion to be proposed in the Patent Office — and committee appointed official declaration of interferences. I am to devote the whole of tomorrow in the examination of the applications for Patents in interference with my patents so as to be thoroughly posted in the whole matter.

Noted Jan. 2d. 1879

Jan. 3d. 1879

Have spent this day in examining Mr Pollok's motion & in studying the interferences declared by Examiner — by means of abstracts of the applications made by Mr Pollok's assistants.

Must examine tomorrow the applications themselves. Mr Hubbard returned to Washington this morning.

Sent off copy of my letter to Nature answering Mr Prescott's charges — to Prof. Watson of Ann Arbor.

Can the forms of the micrometer

for articulate sounds to be studied microscopically or otherwise.

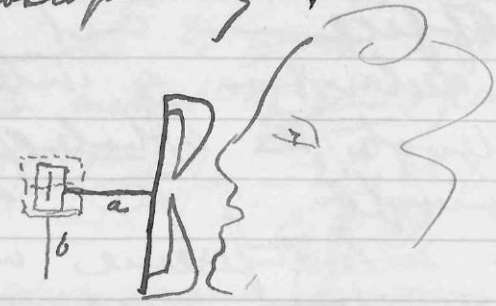


Fig 34

Lit

Notes Jan. 3d 1879
Ag B

(Saturday)

Jan. 4th 1879. Idea shown in Fig 34 is the my old Kaleidophone idea applied to a plate as a means of investigating the shapes of the aerial vibrations for articulate sounds.

A card ~~[illegible]~~ with a vertical slit in it is attached by stem a to the plate or diaphragm. Another card with a horizontal slit in it is supported by stem b. Light can only pass through the point of intersection of the two slits and by moving - b - upwards or downwards or by causing it to vibrate in a vertical direction

Ch. of S. Jan. 20, 1879

The locus of the points of intersection of ~~the two slits~~ will form a pattern under the influence of a sound, and the shape of the aerial vibration be seen directly or deduced.

Another way is to observe the intersection of two ~~dark~~ lines in the ~~pattern~~ way shown by Roy. Wood ~~Hoy~~ but use a plate actuated by the voice as one o

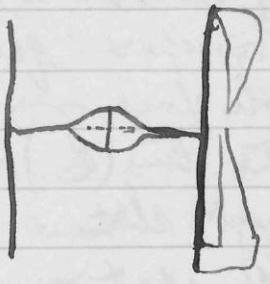


Fig 38

Note matter - cork idea for Roy. Board,
H.

Noted Jan 4: 79
CSP

Saturday Jan. 6th 1878 continued. The forms of the vibrations of vocal sounds may be also studied by observing the point of intersection of two dark lines. One method is shown in Fig 38. A still better plan perhaps is that shown in Fig 39. where a sheet of glass (a) is thrown edgeways into vibration by being supported between two diaphragms (b & c). Upon the sheet of glass there is a fine line (d). This may either be a dark line on the transparent glass — or the whole glass may be darkened and the line (d) be a fine transparent slit.

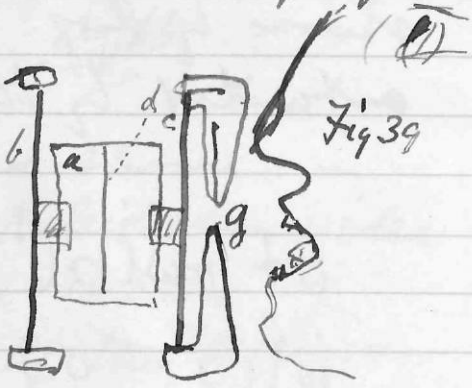


Fig 39

The sheet of glass (a) vibrates backwards & forwards in a horizontal line.

Now if another sheet of glass (e) Fig 40 carrying a horizontal slit or line (f) be caused to move upwards or downwards in front or behind (a) Fig 39 while some sound is being made into (g) Fig 39 — the point of intersection of the two lines will show visibly the form of the vibration.

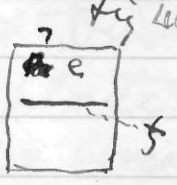
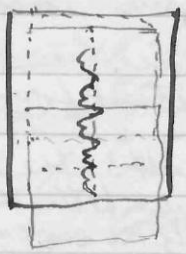


Fig 40

R. F. S.
Jan. 20, 1879

For instance let (e) Fig 40 be moved rapidly downwards then an appearance somewhat similar to that shown in Fig 41 will make its appearance?

Fig 41



If the glass (e) Fig 40 be caused to vibrate edgeways in a vertical direction — then the points of intersection will trace out a pattern somewhat like that in Fig 42 or Fig 43. This plan although probably productive of more striking patterns than the other is not so valuable. The forms will probably not be stable a kaleidoscopic effect will most probably make its appearance. Should it prove however — as may be the case — that the forms do remain stable — it would be a splendid thing for then the shapes of the vibrations could be photographed with ease.

Fig 42

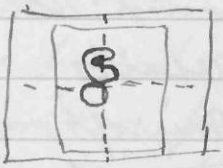
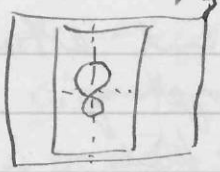
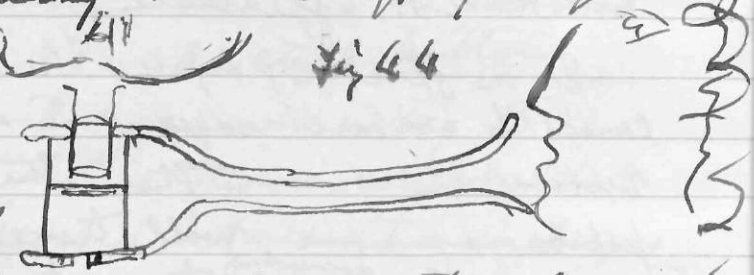


Fig 43



A microscopic photograph would reveal delicate discriminations. It could be enlarged & thrown on the screen indeed the apparent vibrations might be produced upon the screen. Would it be possible to detect by the

eye the various elements of the English Language & appreciate speech optically. Fancy a deaf man looking at the vibrations of the speaker's voice and understanding what he says by the eye.



If a distinct form is formed for every sound — why not this result? The memory of the eye is even better than that of the ear. If the ear can remember a succession of sensations & attach a meaning to that succession of sounds why not the eye. Why should not the eye take in a whole word as well as the ear?

See no reason why this method of studying sound should not be productive of great results. Combined with a telephone & microphone — we may be able to study the characteristic voices in vowel sounds and students of natural History may yet give plates of the voices of animals birds — insects &c — in a way that cannot yet be dreamed of. Perhaps also these plates may be of such a nature that the sounds recorded may be rendered audible from the plates by some development of the Photo-Phonographe of Mr Brown.

Fancy a man passing a little pencil of Selenium over a record in a book and thus hearing the sound produced!

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The possibilities of science are almost too marvellous for belief — and one must really be careful not to speculate too rashly. These things may be — and we may look ahead and see the forms of things that will be slowly taking shape and acquiring consistency but we must not wander too far from the present. Step by step! little by little! We may plod along slowly and painfully turning the unknown and occasionally looking back we may note the direction in which we have travelled & it is natural to look ahead in the same direction for our future path.

Still the man who has his gaze fixed upon the distant horizon is not half so safe as the man who scans the ground at his feet — and it may be wiser in me to look first to the nature of the path I am treading — & see that I am on good solid ground — before raising my eyes to follow the direction in which I am going into the distance. Yours &c

I saw for the first time this morning a letter from W. David Brooks of Philadelphia

which had originally been published in the Philadelphia Times - but which I saw in a number of the "Journal of the Telegraph" dated the 16th of December, which had been forwarded to me by Mr Watson. I wrote a reply to it this evening - but do not intend sending it in until I have gone over it very carefully - and have had Mr Hubbard's advice about it.

Noted January 6th 1879

A.G.B.

Thursday Jan. 6th 1879

Too late tonight to note experiments, thoughts, and proceedings of this day - Must leave them for tomorrow - Shall merely note for my guidance tomorrow the heads to be developed.

Letter to Editor of Philadelphia Times
Statement of Invention to Ex. Com. of Bell Tel. Co.
Water pipes — W. Hubbard gone to Rutland.
Gertrude — Friction Telephone a great success. Bowls of old experimental debris.
Letters to Watson & Connick. Mabel's Journal.

Noted Jan. 6th 1879

A.G.B.

P.S. Don't forget to note the weather-cork idea and multiple friction contact idea. A.G.B.

(R. J. S. Jan. 20, 1879)

Monday Jan. 6th 1879 — My may not frictional ideas be ~~applicable too~~ used without a battery. Statical Electricity is produced by friction. Let the friction motion be produced by the voice — and why should we not hear the effects produced by the frictional electricity conveyed in this way. Perhaps simply the friction of unlike substances may do. Try zinc upon silver as in Fig 45.

Also try glass upon silk as in Fig 46.

Fig 45

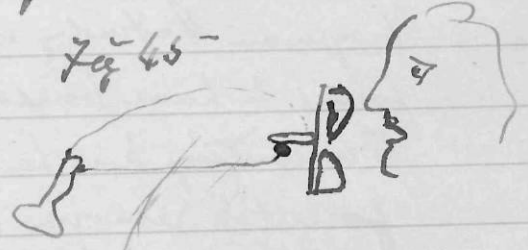
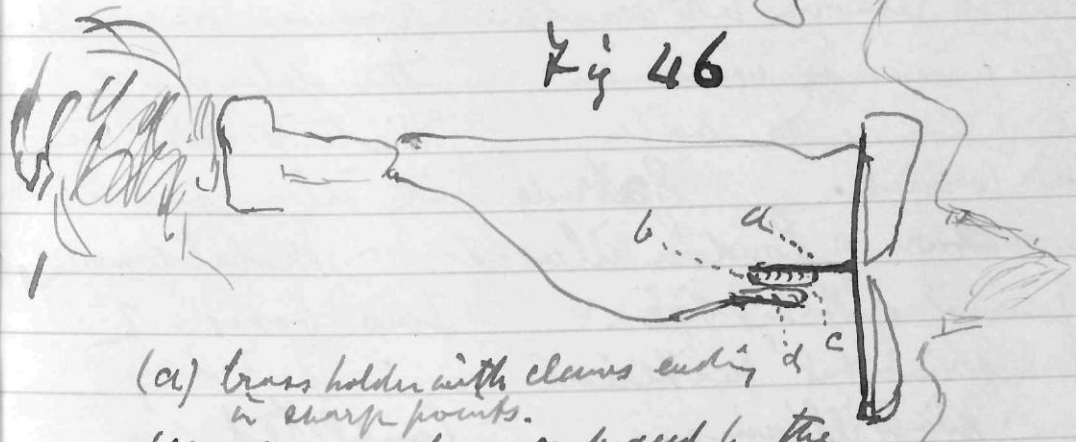


Fig 46



(a) brass holder with claws ending in sharp points.
(b) glass rubber — embraced by the claws which are to collect the electricity produced by the friction
c — silk rubber
d — metal holder with claws.

Worked. Jan 6th 1877 at 20 clock at night

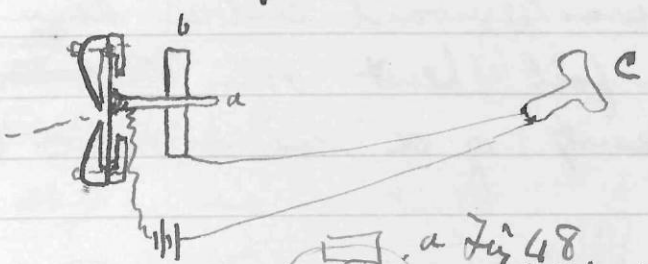
Monday January 6th 1879 — Extent of experiments

Letter to the Philadelphia Times answering W. Brooks' charges in that paper was posted. This morning — and I occupied the greater part of the forenoon in writing a statement of the History of my Improvements in Telephonic Circuits — ~~which is to be~~ forwarded to the Executive Committee of the Bell Telephone Co. —

Our water-pipes which were frozen on Saturday were thawed out to-day and were found to have burst under the floor of my study. Our writing has been interrupted and we are forced to remove into another room on account of the presence of workmen & the delaying of the room with water. Wrote to Mr Watson & Mr Cornish. Gertrude quite ill — feverish — fear return of London illness. Mabel commences a Journal of Baby's life. Two boxes of old experimental material received to-day from Mr Williams. Completed a friction carbon telephone to-day as in Fig 47.

N. J. S.
Jan. 20. 1879

Fig 47



a Carbon attached to membrane by gutta-percha

b. Carbon fixed upon which (a) is caused to rub when the diaphragm vibrates.

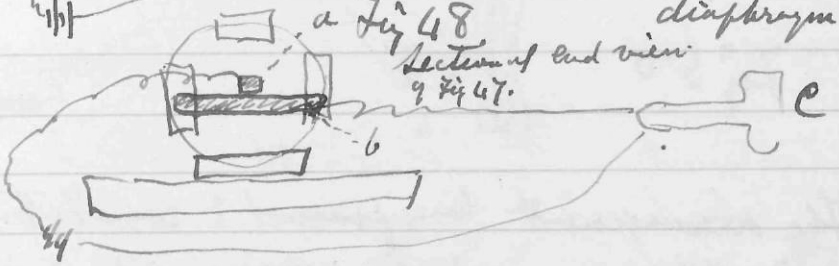


Fig 48
Sectional end view of Fig 47.

This instrument was completed the Sunday and was found to work very successfully. The loudest clearest and most distinct articulation I have ever heard proceeded from telephone c when Harry Simmons talked into the Frictional Telephone.

A band of indian-rubber was arranged as in Fig 49 at d so as to exert a constant and gentle pressure on a. Articulation remarkably perfect & loud. Could recognize what was said at any part of the experimental room upstairs (1509 N.Y. av. Washington D.C.) in a rather loud conversational voice. Arrangement not quite as sensitive to feeble sounds as Hughes upright Microphone.

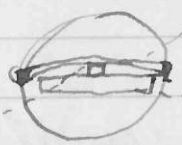
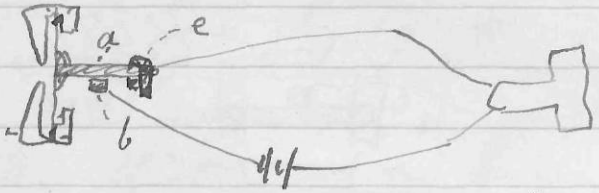


Fig 49

Rubber band was removed and a small strip of brass-foil (e) bent over the ~~end~~ projecting extremity of a as in Fig 50

Fig 50

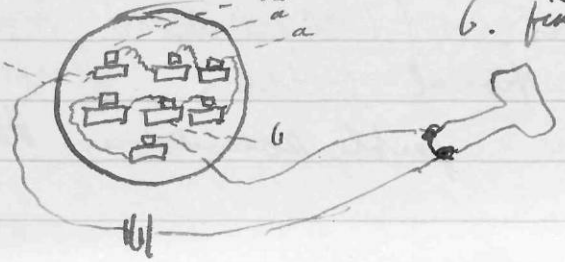


The arrangement was found to constitute a true microphone — but it seemed to be available for ~~sounds~~ sounds of all loudnesses. The loudest shouting did not cause it to "break". The quality of the voice was evidently preserved ~~even with~~ The loudest articulation. I am convinced that the preceding idea constitutes a valuable improvement in regard to Battery Telephones.

My effort of combining a number of carbons in series & in multiple arc — as in Figs 51 & 52

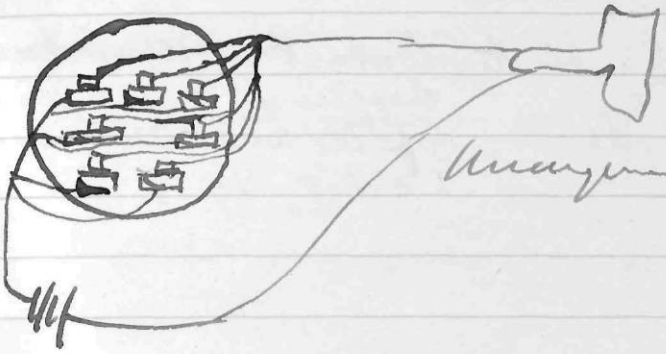
a — Carbons attached to plate
b. fixed carbons against which they rub.

Fig 51



Ch. J. S.
Jan 20, 1879

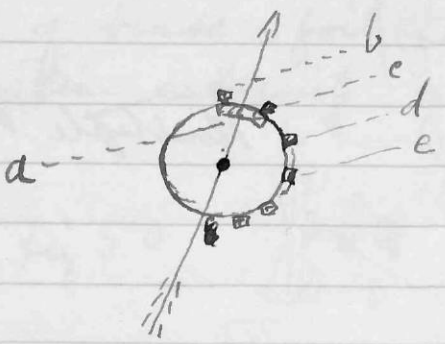
Fig 5-2



Arrangement in Multiple arc.

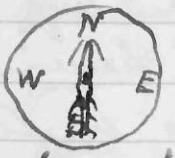
I was at Prof. Baird's house the other evening (Saturday) & he stated that he had a cable of eight wires to the top of his house for the purpose of having an electrical apparatus in his study that should indicate the direction in which the wind blew. He had an electro magnetic indicator for each wire - and the clicking of the electro magnets was so annoying that he had to have the apparatus taken away. I immediately suggested the following arrangement which he seemed to think highly of. Arrange the weathercock so that its contact piece shall always be upon one wire and may rest upon two as shown in Fig 5-3.

Fig 53
Electrical weather-cock

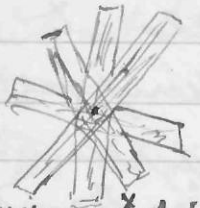


a. Contact of the vane sufficient to cover two of the wire terminals b, c, d, e, &c.

Fig 54
Steering Indicator



Needle and card



arrangement of coils affecting needle

Suspend a magnetical needle over a number of coils of wire centrally arranged upon the same general idea as that shown in Fig 54 Connect each coil with one of the wires leading to the weather-cock and to one pole of battery. Connect contact piece (a) Fig 53 with the other pole of battery, Then magnetical needle will place itself across that coil which is connected with the wire touched by the weather-cock – and can thus be made to indicate the point from which direction of the wind. Should the ends of two wires be covered as in Fig 53 – then the needle

in the radiator being influenced by two coils will take up an intermediate position. Thus the needle can indicate a larger number of points than there are wires.

Supposing the vane to have two contact points instead of one — and each contact point to be connected with one pole of the battery — not only could points intermediate to two wire-terminals be shown — but the indications could be doubled by the reversal of the battery.

Noted January 8th 1879

A G B

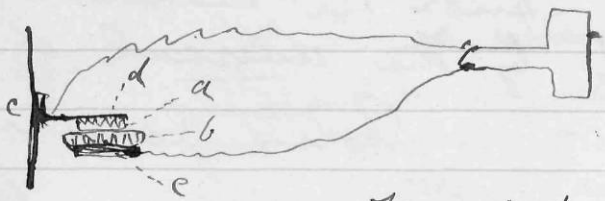
Tuesday January 7th 1879

Tried other substances in my frictional Telephone beside carbon. A brass wire fastened to the centre of the diaphragm was caused to rub against another piece of brass. Unsatisfactory results. The wire attached to the diaphragm was thick and inflexible and very short — about 3/4 inch in length — so that it was difficult to get it to rest lightly on the other brass. Had we had got

Articulate effects. A brass spring or flexible tongue was tried with rather better results. The experiments show the correctness of the method — and I shall have good instruments made soon.

An apparatus to produce frictional electricity by the voice was made to day.

Fig 55



a - ceiling wax
b - silk
c - diaphragm.
d - brass spring with tinfoil teeth reaching down on surface of shellac almost to the surface in contact with the silk
e. Similar tinfoil teeth going almost to the ~~paper~~ by the silk rubbed by the shellac.

The object of the tinfoil teeth is to collect the electricities produced by the friction and lead them away to the distant telephone.

Fig 56

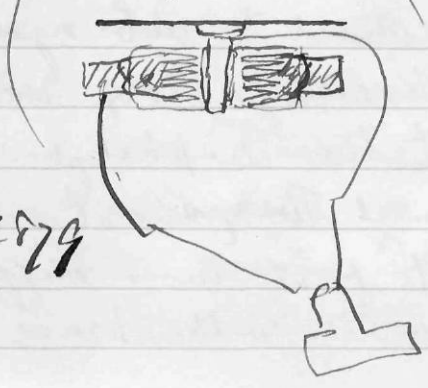


Fig 56 shows plan view of this form of apparatus.

Noted January 8th 1879
by A.G.B.

A. G. B.
Jan. 20, 1879

Wednesday January 8th 1879

Tried experiments with frictional telephone shown in Figs 47, 48, 49 & 50, and am confirmed I have struck an important and valuable form of apparatus.

Gravity battery does not seem so well adapted as Battery of higher tension.

~~2 cells (small)~~ 2 small cells of Bichromate Battery — produced much better results than 10 cells Gravity Battery.

Frictional Telephone shown in Figs 46, 55, & 56 may perhaps be combined with ~~telephones~~ Condensers. Worth thinking out.

In order to produce loudest effects with a talking telephone — we want a means of sending the current in one direction when the plate moves one way & a current in the inverse direction when the plate moves in other direction.

May not apply ~~Gutta~~ Hotel Annunciator

Idea to Electrical Weather-cock.

Baby went out today for the first time since she came to Washington. Wife, husband and nurse took her out in her perambulator for about five minutes. Elsie is eight months old today.

Received Nature for Dec. 12th and for Dec. 19th 1878. Letter from Prof. Barrett in Number published Dec. 12th in answer to Prof. Watson. Letter from Dolbear dated July 8th 1877 and giving the dates of all his discoveries and inventions (Intatoh Harbor) Received today from Canada, where it has been ever since our marriage.

Noted Jan. 8th 1879

by A.G.B.

Jan. 10th 1879

Fig 57

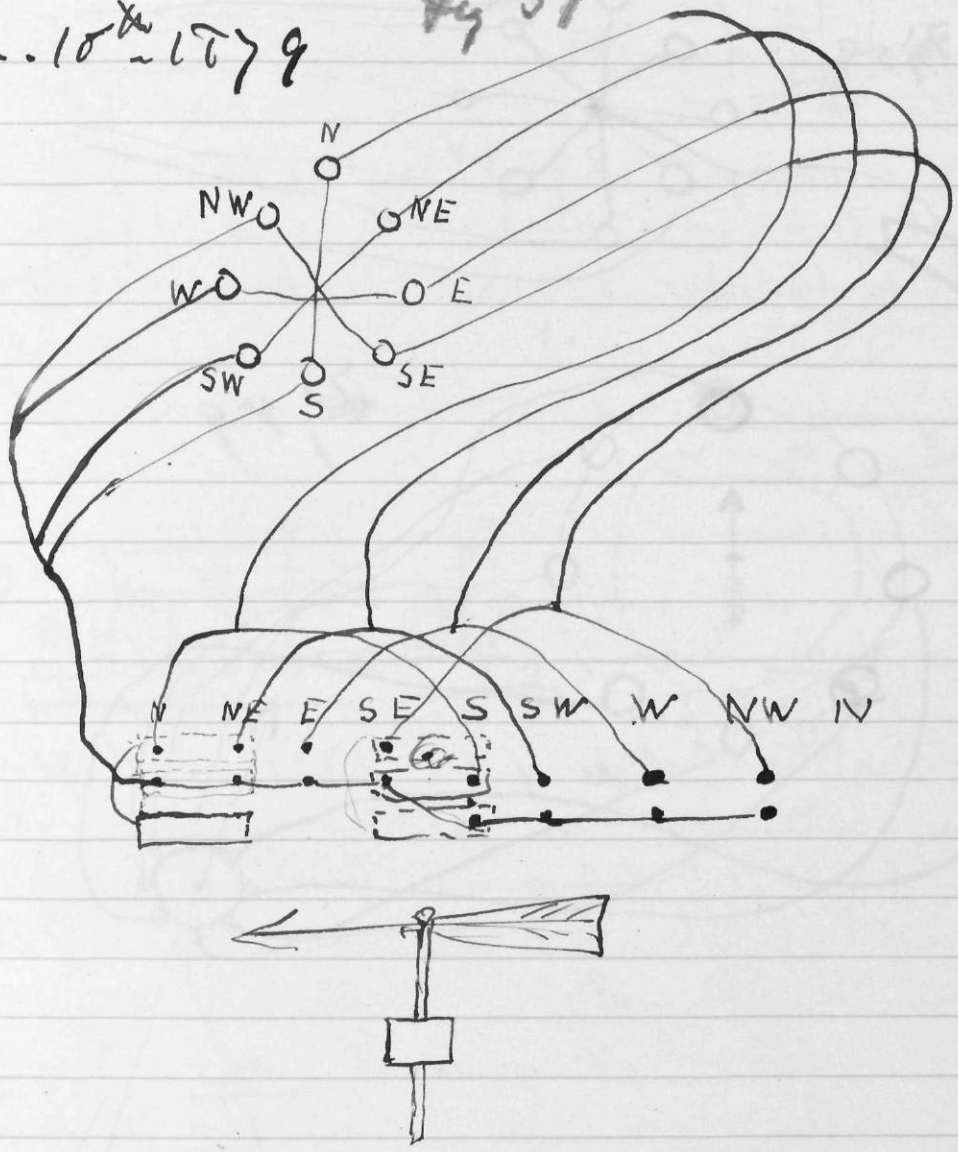


Fig 58

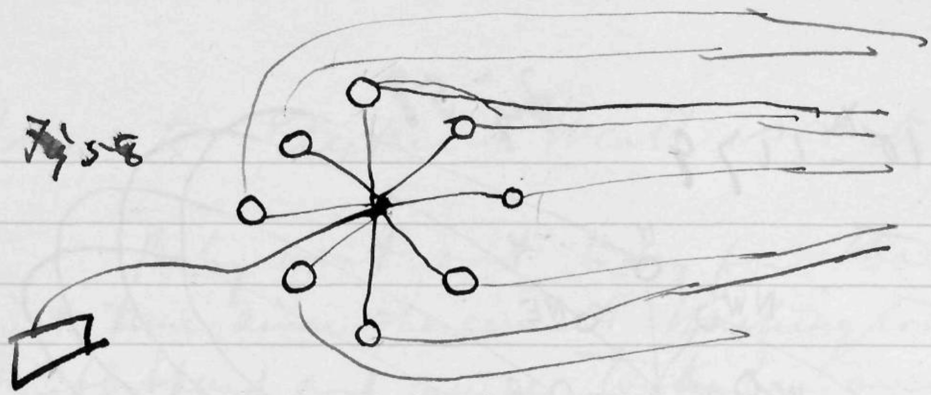
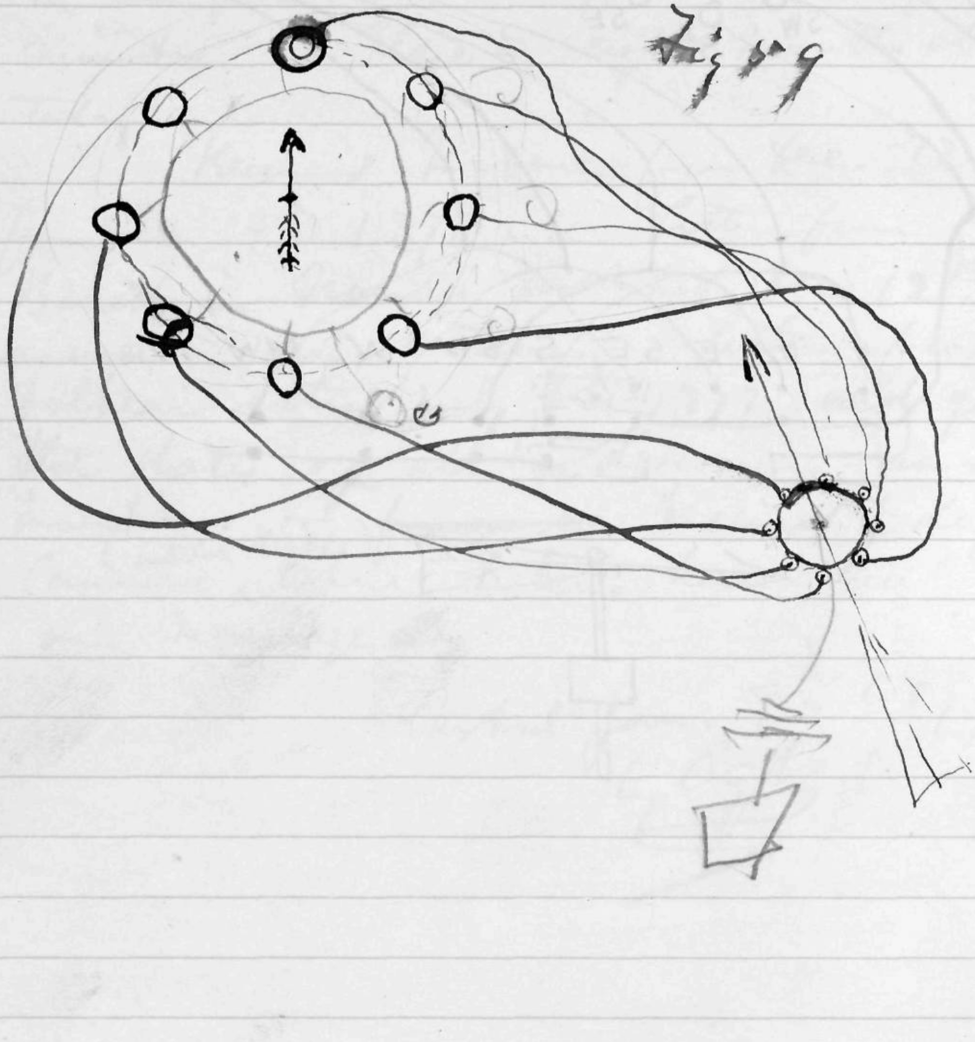
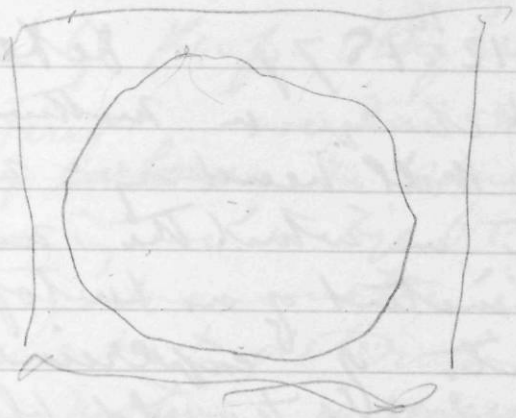


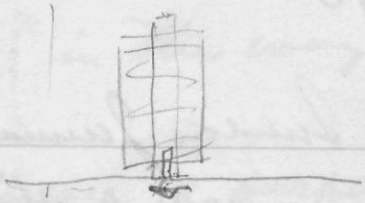
Fig 59



A. J. S
Jan. 20, 1879

5'9





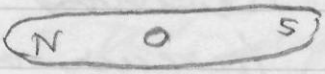
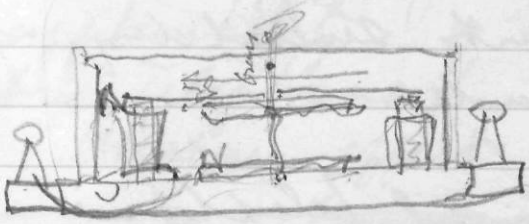


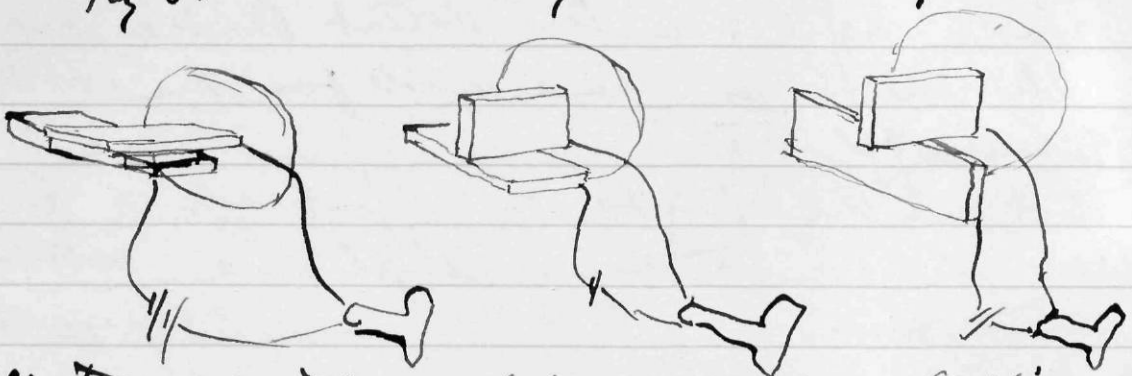
Fig 60



Sunday January 12th. 1879 Determined to make a slight change in method of notation. Will head my notes with the date on which the notes themselves were made instead of as heretofore with the dates of experiments themselves. I find the old plan difficult to carry out as I often have to note experiments several days after they were made.

Inductional Telephone — test influence of surface upon result. Try following varieties of apparatus.

Fig 61 Fig 62 Fig 63



Also try a variety of substances such as Antimony Manganese (Black oxide compressed into cakes) & brick and other

(R. D. S. Jan. 20, 1879)

porous materials "metallized" in the way shown by Prof. Hughes.

First ascertain influence of surface by taking carbons of the same size & weight and arranging as in Figs 61, 62, & 63. Then when a galvanometer is accessible repeat experiment to determine whether the sliding motion increases or diminishes the resistance for upon this depends the applicability of this to a Magneto-Electric Telephone!

Ascertain effect of ~~electric~~ combining a number of ~~carbons~~ sliding contacts in series and in multiple arc.

Saw W. Bollok this morning at his office. Spent yesterday in Baltimore at the office & workshop of Mr Davis & Watts. Had a model of a frictional carbon telephone made to put in the Patent Office tomorrow. Also gave orders to have made for me (1) an Experimental Friction Telephone on base so that all the parts are adjustable & removable (2) A portable Friction Telephone ~~constructed~~ on the principle of that shown Fig 35 page 36, and (3) An electrical Vibrating Detector on the principle shown in Fig 59 page 58.

Patent forwarded to U.S.P.O. Jan 21st 1879

Sunday Jan 12th 1879. A very important thought has just come to me upon considering the action of the apparatus shown in Figs 37, 38, 39, 40, 41, 42, 43, 44.

In Fig 37 one of the sheets of glass is to be thrown into vibration by the voice and the other to be moved mechanically. Now why cannot both sheets be moved simultaneously by the voice in the same manner. This idea has occured to me many times but I have always immediately dismissed it under the idea that the figure traced would always be a circle if both sheets were moved in the same manner. However Mabel has just demonstrated to me that this is not the case. We took a piece of paper and a pencil: Mabel moved the pencil pendulously while I moved the paper in a similar manner underneath but at right angles to the motion of the pencil.

Result — a circle.

Mabel then moved the pencil so as to produce

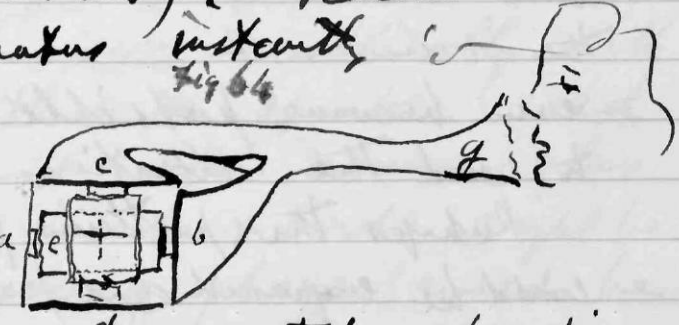
(R. H. S. Jan. 20, 1879

a tracing of the following kind when the paper was dragged uniformly under the paper:-

When the paper was moved in the same way ~~a compound~~ a figure made its appearance that bore no resemblance to a circle. I see now most clearly that circles would be produced only by the rectangular combination of two simple pendulous vibrations — and that the rectangular combination of any other kind of vibration would produce for each quality of sound a definite ~~form of vibration~~ figure not a circle. (The two rectangular components being exactly similar vibrations).

Make following apparatus instantly

Fig 64



a, b, c, d, metallic diaphragms
e, f, sheets of glass
carried respectively
c by a, b, and f by c, d,

The speaker's voice is led through speaking tube g, by a bifurcation of the pipe to the membranes b & c thus causing similar vibrations in both sheets of glass and a definite complete pattern

should make its appearance at the intersection of the lines. If one of the plates were to be vibrated in some mechanical manner - it would certainly happen that many sounds would not yield a complete figure but the figure seen would pass through a succession of phases - and thus would not present a permanent form but a changing kaleidoscopical appearance.

But with the present arrangement since the rectangular vibrations are always alike in period and form - a definite and permanent form should be attained which could be photographed - and deaf pupils could be given the photographs and instrument and taught themselves the various sounds - and it might even become possible to teach them to read the vibrations of speech at sight.

Perhaps the patterns for the English sounds could be engraved and printed from types so as to form a new natural alphabet and books could be printed in such characters so as to accustom deaf

persons to the shapes of the vibrations.

If a certain quality of sound is distinguished by a certain shape of vibration in all pitches as is probable then the shapes of the English Elements of Speech should remain constant in my Vocal Kaleidophone — whatever the pitch of the voice might be — and the shapes of the vibrations would only change with the quality.

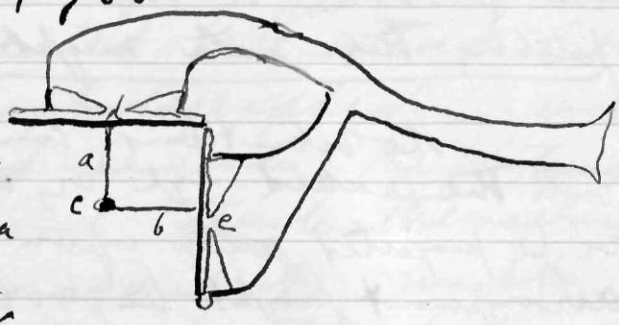
Thus a simple pendulous vibration would always show a circular ring whatever the pitch of the note might be.

The vibrations could be observed directly with the naked eye or with a microscope or be projected upon a screen. The arrangement might be worked electrically with a microphone so that the speaker need not raise his voice and in this manner also the sounds produced by insects & birds might be studied. The influence of phase could be studied by shortening or lengthening one of the pipes below the bifurcation so as to cause the vibrations of the voice to reach

the plates in different phases. The idea of causing the the rectangular vibrations to be always identical in periods — is a most valuable thought — and it seems to me must open up a whole new world of investigation in regard to sound. Let me be the first to make & use this instrument and to study & photograph the forms of sounds.

Why not make it into a new sort of phonautograph.

Fig 65



Attach two light rods (a, b) to the centres of the two diaphragms d, e, and at their point of junction (c) have a pencil or glass pen — or a simple style resting by its own weight upon a piece of plain paper (of a pencil or pen) or upon a sheet of smoked glass or smoked paper if a simple style.

Chemically prepared paper could be placed below and a current passed from the style through the paper. While the glass idea would be best for the actual examination of sounds — yet

R. S. Jan. 20, 1879

The phonautograph plan would be probably the simplest way of obtaining a record.

Fig 66

Another idea. Fasten the opaque surface (a) by ~~[illegible]~~ of a square shape by its four corners to the centres of four diaphragms b, c, d, e, and make a small pin hole in the centre of it at f. Cause b, c, d, e to vibrate and a pattern will be produced at f. This is better than the intersection of two slits as the it would be difficult to focus both slits and this would lead to a ~~[illegible]~~ blurring of the figure unless the amplitude of vibration were great. By the by the diameter of the figure obtained would be a measure of the loudness of the sound.

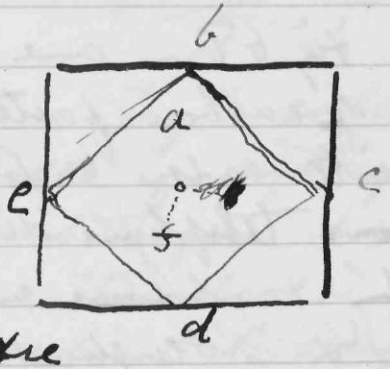
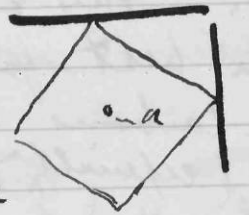


Fig 67

Another idea see Fig 64.

Support square sheet by two corners & let it rest on a sheet of glass.

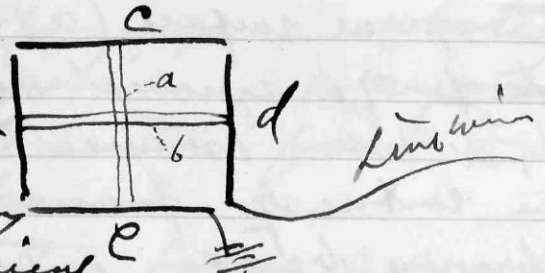
The centre spot (a) Fig 67 need not be a hole in an opaque ~~[illegible]~~ surface but a black spot on transparent glass.



Another idea — Apply principle to obtain greater frictional motion than with one moveable carbon.

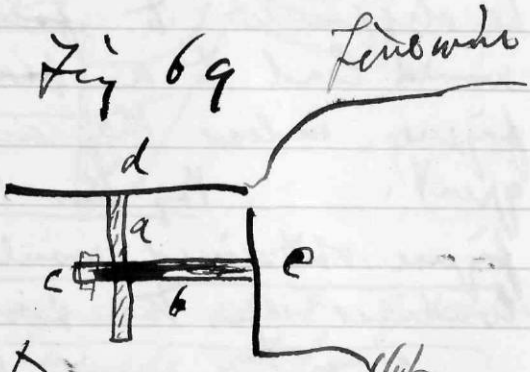
Fig 68.

a & b Fig 68 — are two rods of carbon fastened by opposite ends to four telephone diaphragms c, d, e, f. Some mechanical arrangement is employed to keep them in contact at their points of junction. Plates c & d are vibrated simultaneously by the voice and the frictional of a & b is doubled as both carbons move.



Another plan. Two carbons (a & b) Fig 69 attached to two diaphragms d & e. & upper carbon b brought into contact with a by adjustable weight. This seems to me to be the best form of frictional Telephone.

Fig 69



The carbons are rigidly attached to their plates (especially the under one a). The diaphragm e will certainly give sufficiently under the influence

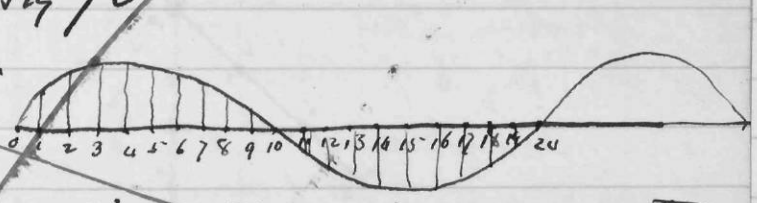
A. G. S.
Jan 20, 1879

of the weight C to bring the contacts in contact

Notes Sunday Jan. 12th 79
by AGB

Sunday Jan. 12th 1879 Try & calculate effects produced and see if anything really valuable can be obtained before having apparatus made. The idea is easily capable of demonstration it seems to me by calculation. Given a certain vibration what shape or form should be produced with apparatus shown in Figure 64 page 63.

Fig 70



Let Fig 70 be a vibration impressed on the two plates. ~~Let the ordinates of the curve~~ The abscissas represent intervals of equal time & the ordinates express the motion of the vibration. Let

Obs

ab.	ord.		
0	0		
1	1		
2	2		9 – 2
3	3		8 – 3
4	4		7 – 4
5	5		6 – 5

Fig 70

Motion of vibration as ordinarily expressed. to be imposed on the two plates.

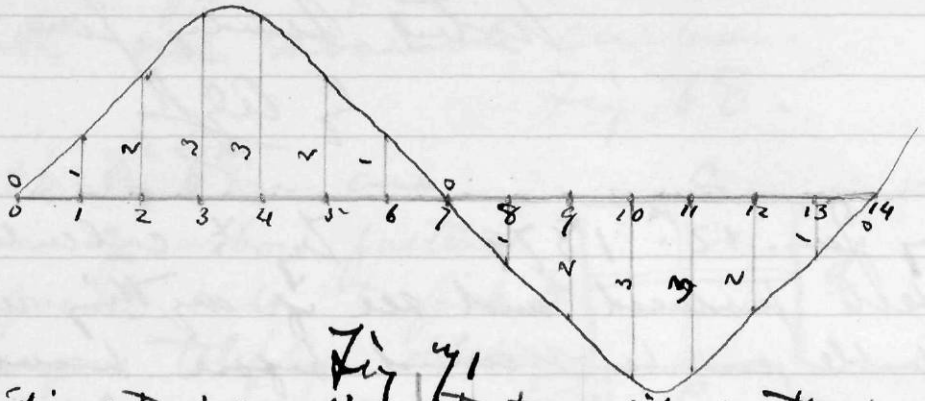
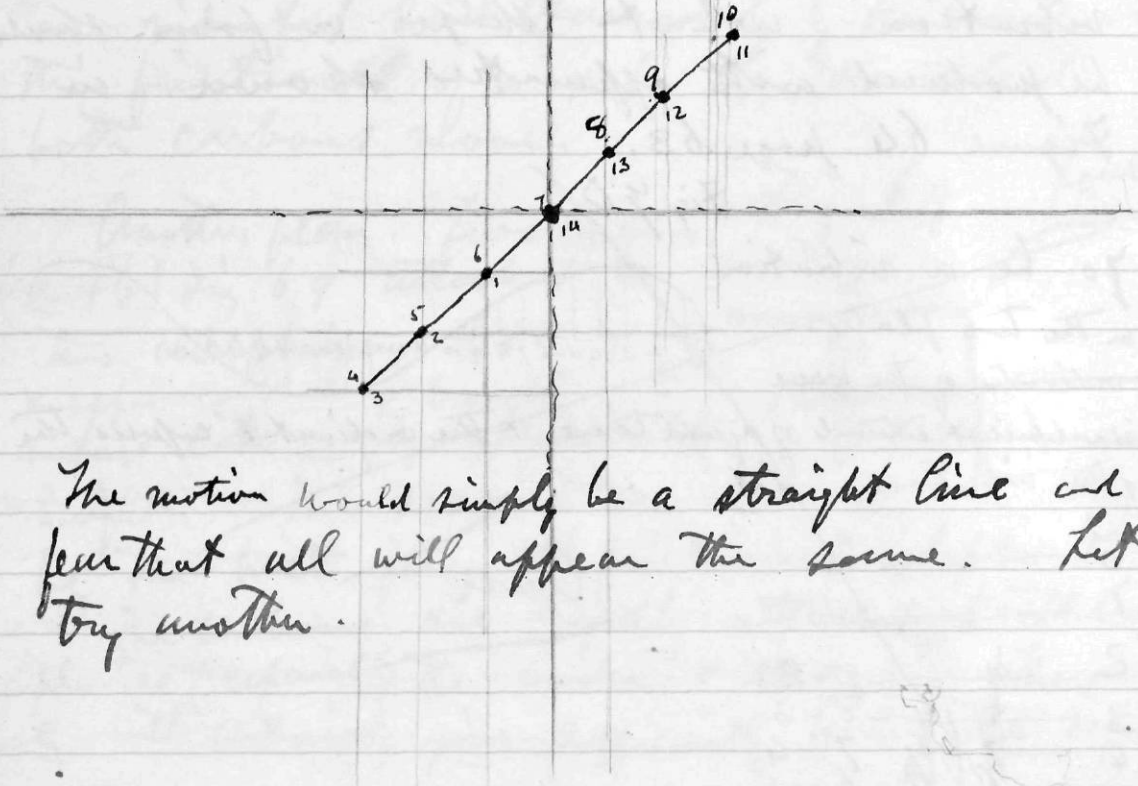


Fig 71

The position of the intersection of the two slits ~~on the~~ at the times marked 1 2 3 4 5 6 7 &c in Fig 70 will be as follows.



The motion would simply be a straight line and I fear that all will appear the same. Let us try another.

A. G. S.
Jan 20, 1879

Fig 72

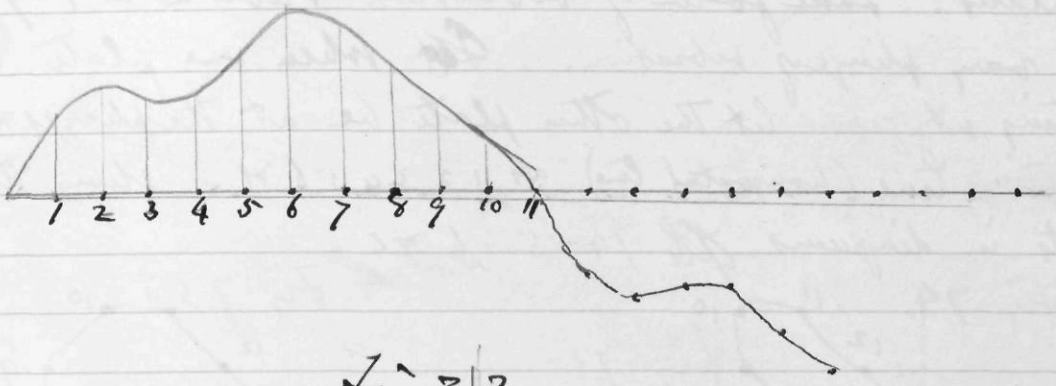
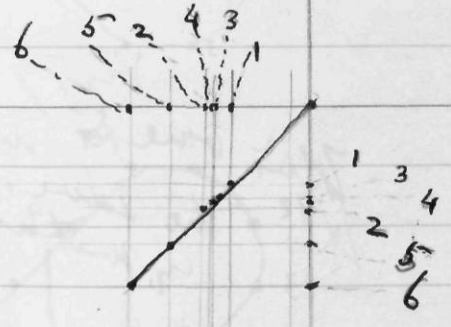


Fig 73



Actually seems as if all forms of vibration would appear as straight lines and no forms be observable at all. This shows how cautious one should be in speculating and not allow ideas to run away with him without checking off his conceptions in every possible way by calculation & experiment.

Calculate effect of varying the phase of one of the plates. Take form of vibration shown in Fig 70 and vary phase of vibration. When one plate is starting at zero let the other plate be at the phases marked on the time line (horizontal line) as 1 2 3 4 5 6 7. Show the results in diagrams 74 - 5 - 6 & 7

Fig 74

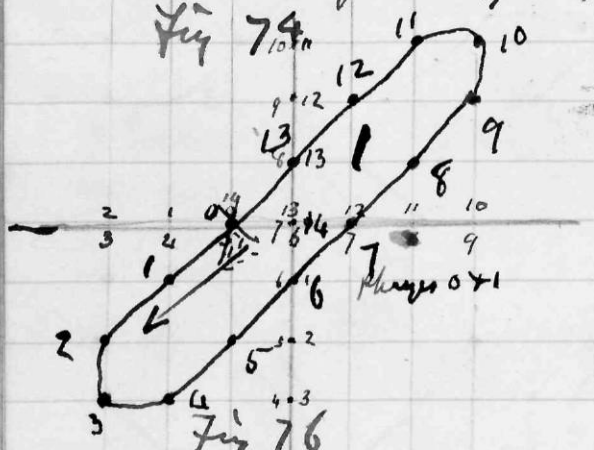


Fig 75

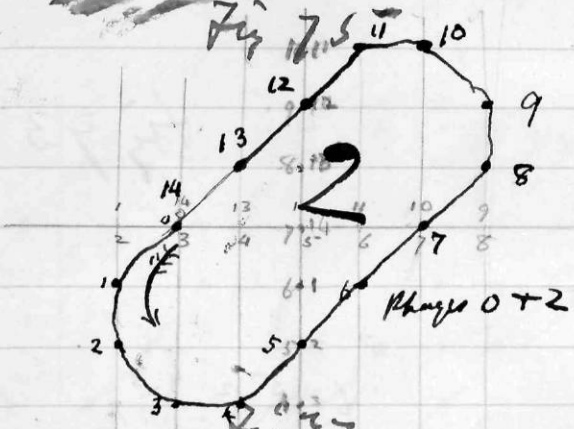


Fig 76

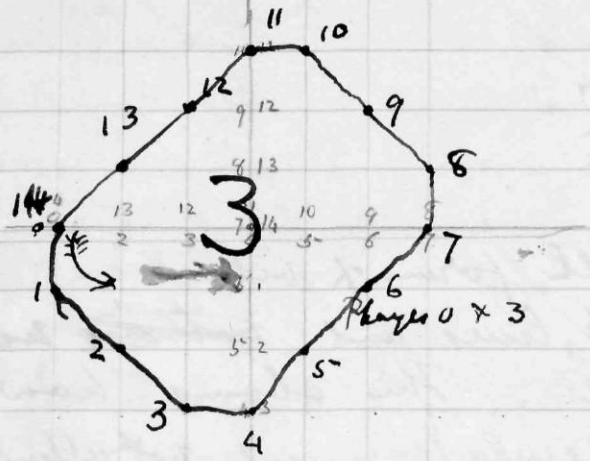
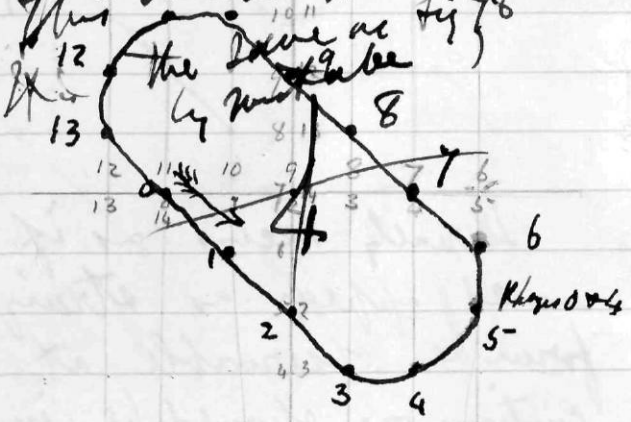


Fig 77

This one is incorrect the curve should be as in fig 78



Ch. P.S.
Jan. 20. 1879

Fig 78
Charges 0 + 5⁻

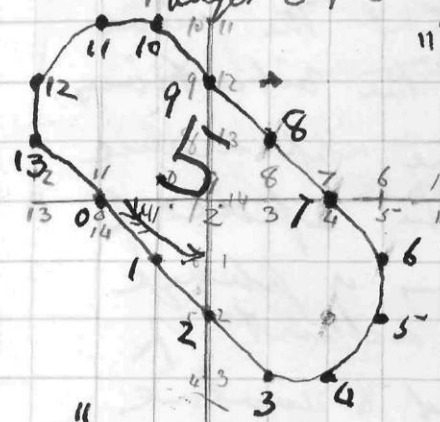


Fig 79
Charges 0 + 6

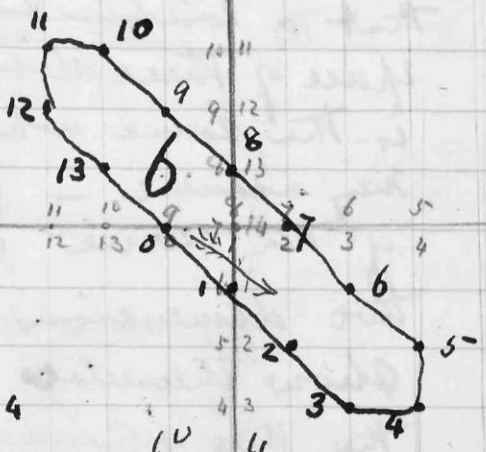


Fig 80
Charges 0 + 4

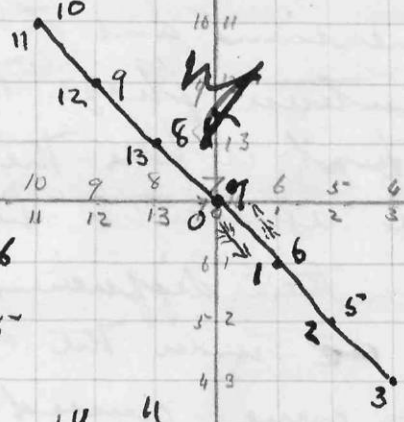


Fig 81
Ph. 0 + 8

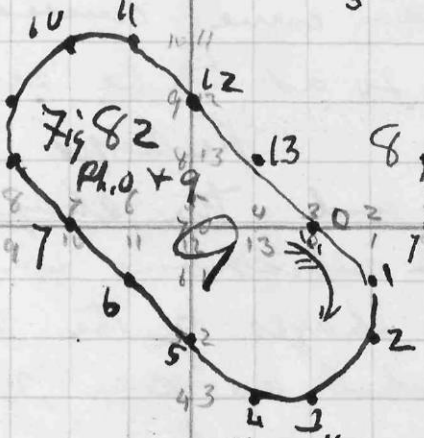


Fig 82
Ph. 0 + 9

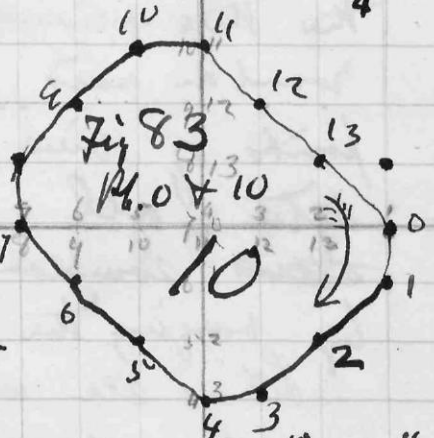


Fig 83
Ph. 0 + 10

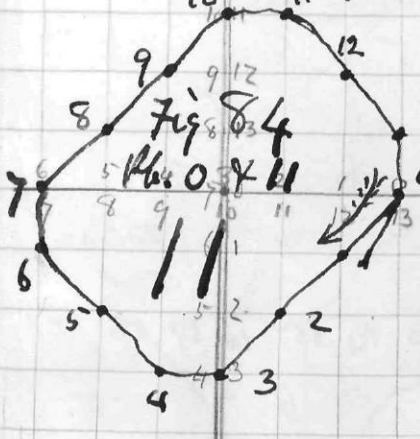


Fig 84
Ph. 0 + 11

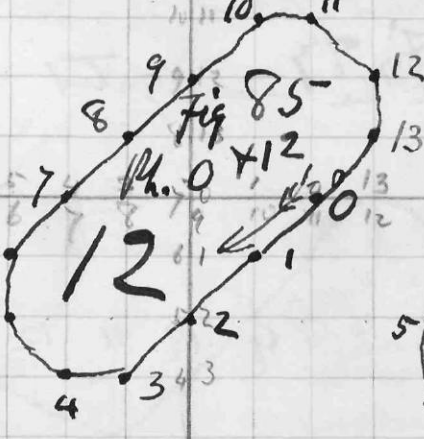


Fig 85
Ph. 0 + 12

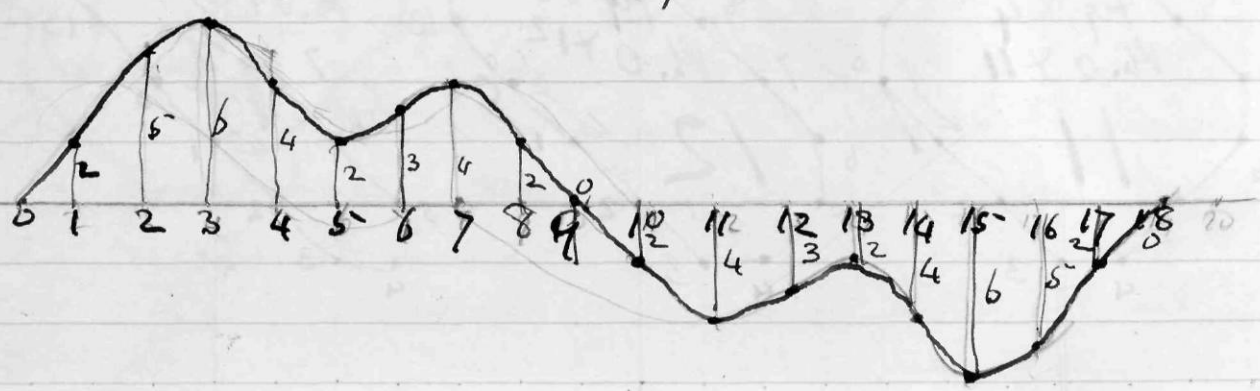
Fig 86
Ph. 0 + 13

These appearances are consistent with the idea that a combinational curve is a curve in space of three dimensions and that the curve is the same whatever phase the vibrations may assume — but when the appearance of the curve is represented in space of two dimensions — then differences of phase show themselves ~~as~~ under the aspect of the three-dimension curve caused to revolve round an axis so as to be seen from different points of view. Perhaps I am right after all and the shapes of ~~the~~ ~~sound~~ vibrations may be observed by varying the phases of the vibrating plate.

Let us see what we can make of a curve of a different kind.

Fig 87

Curve to be investigated



The series of ordinates are as follows.

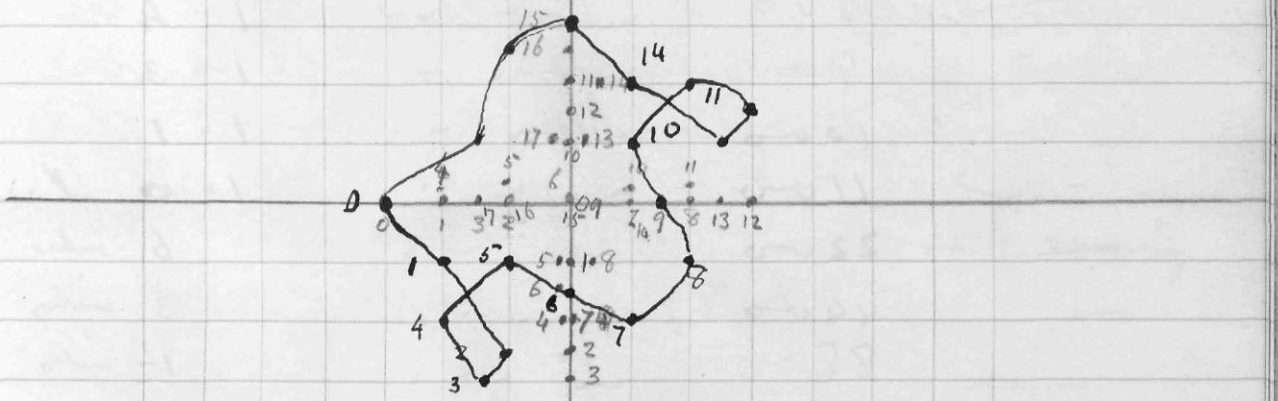
0	2	5	6	4	2	3	4	2	0	2	4	3	2	4	6	5	2	0	∴
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	0	abscissae

~~First table plates~~

Fig 88

Phases of plates & abscissæ scale: ● and 3

Fig 88



It is evident I am right after all — but it will be necessary to ~~[illegible]~~ make some arrangement of pipe so as to vary the phases of the two ~~[illegible]~~ rectilinear vibrations. The two vibrating to produce the best effect must be a quarter phase apart.

The length of telescope pipe sufficient to cause a complete revolution of the phases — calculating velocity of sound as 1100 ft per second.

For a sound of	vibrating per second	Length of pipe.
	100	11.00 ft inches
	200	5.06 ft
	366	3.00 ft.
	400	2.09 ft
	500	2.00 ft
	600	1.10 ft
	700	1.7
	800	1.4
	900	1.3
	1000	1.1
	1100	1.00 ft.
	2200	6 inches
	4400	3 inches
	8800	1½ inches

It is evident that as we only require diff. of a quarter phase a three-foot pipe will do. Perhaps an arrangement like the following will economise space and give us all the variation we want.

R. J. S.
Jan. 20, 1879

78.

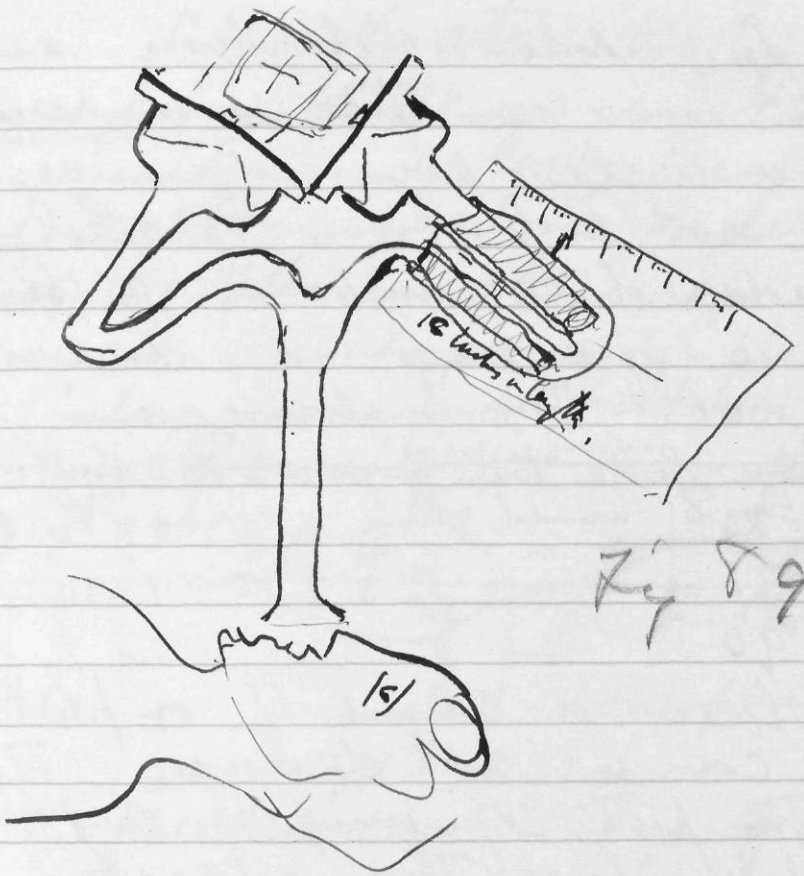


Fig 89

All the foregoing noted this evening
Sunday January 12th 1879

78

Thursday Jan 16th 1879

The simple pendulous vibration is precisely the same as ~~the~~ a uniform motion in a circle seen edgeways. Why should not vibrations of all kinds be reduced to uniform motions in a figure of some kind seen edgeways. For instance: ~~A vibration like the figure 8.~~ uniform motion in a fig. 8 would give a curve of this kind

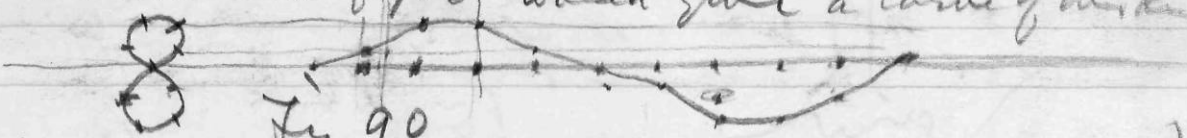
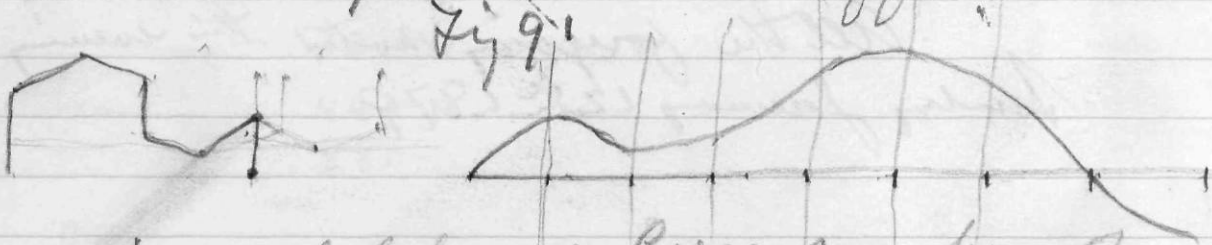


Fig 90

Given a curve of a particular shape — can we not deduce the form of the path of uniform motion that would produce the effect

Fig 91



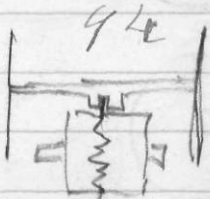
We could deduce a large number of different shaped paths that would indicate the observed curve. Why not try the synthesis of sound as suggested to Sir W. Thomson. Sir William

R. J. S.
Jan. 20. 1879

Seemed much struck by the idea. Could I not construct a curve theoretically on a large scale and then have it photographed or reduced and applied to a phonautograph. If I could manage to have a ridge placed upon a cylinder or an indentation cut as in Figs 92 + 93 then the groove or the ridge could be fitted to a corresponding ridge or groove and move a diaphragm or diaphragms as in Figs 94 + 95.

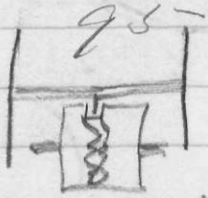
Fig. 92

Fig 93



Ridge fitting into groove

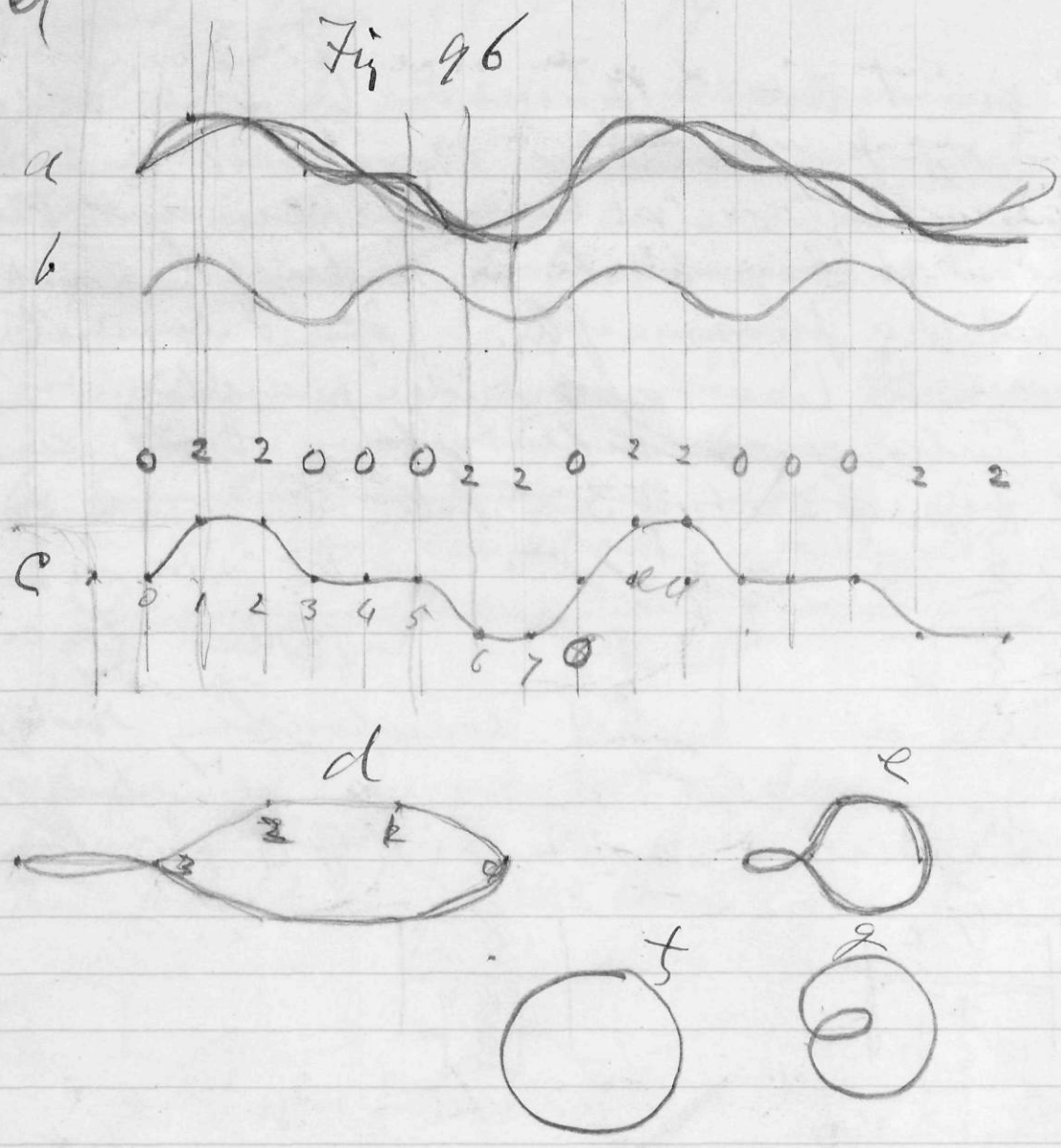
95



Groove fitting ridge

80

Fig 96

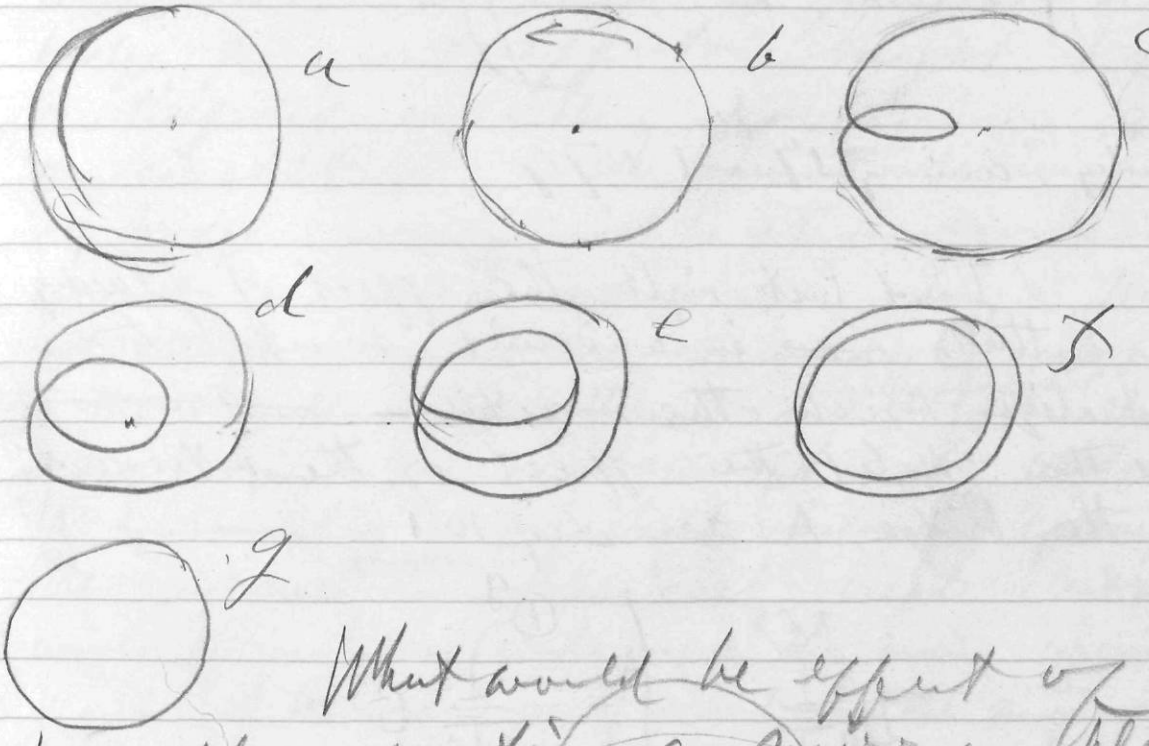


A. J. S.
Jan. 20. 1879

88

Appearance of a pure musical tone and the gradual appearance of its octave the amplitude of the octave note gradually increasing until the upper note is left alone

Fig 94



What would be effect of two styles operating a mirror placed obliquely.

ab styles c mirror

Fig 99

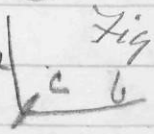
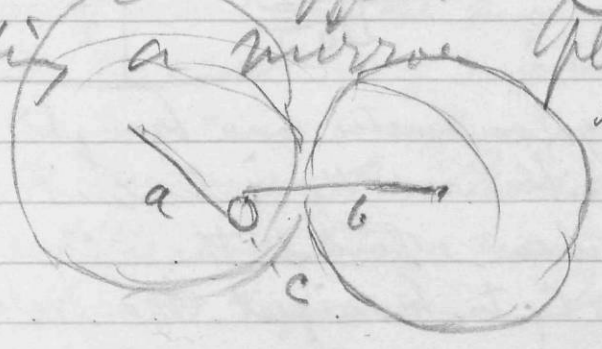
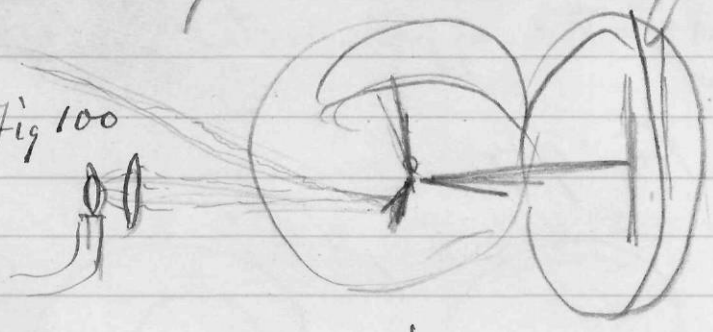


Fig 98



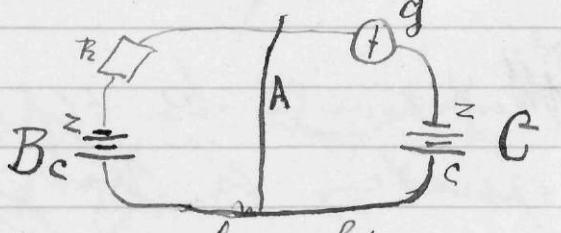
Or let both styles be attached to the same point of the mirror not being the centre of it

Fig 100



Friday January 17th 1879

I tried last night the effect of placing two batteries ~~near~~ in a circuit so as to neutralize each others action ~~and was~~ and then noted the effect of the introduction of the bridge A see Fig 101



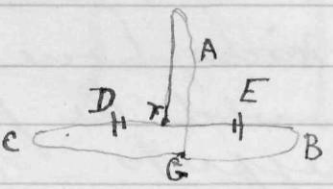
The galvanometer was brought as nearly to zero as possible and the introduction of bridge A of course allowed the currents from batteries B & C to manifest themselves very promptly

R. J. S. Jan. 20. 1879

on their own halves of the circuit. A very slight difference in the resistance of A made a great difference in the manifestation of the current in the circuit under observation in which was placed the galvanometer (G). If a microphone or battery-telephone should be placed in bridge A great effects might be anticipated on other portions of the circuit. As resistance diminishes on bridge currents will be strongest on rest of circuit and vice-versa. Query — Would not strength of current on circuit of C be proportional to the strength of the battery C and inversely proportional to the resistance of the bridge A? And would not Bridge A (if of very slight resistance) by varying its resistance microphonically create electrical waves of great amplitude upon the main circuits. Would not the variations of current on the main circuits be inversely proportional to the variations of resistance of A. For instance given a certain current on main circuits & a certain small resistance of A. Now double resistance of A will not the current on main circuits be just half of what it was before? — No.

Let Resistance of A be infinite. Then the current on the line is at zero. ~~and let~~ If the resistance of A be infinitely small and the current is at a maximum. Current must vary between these two.

Fig 102.



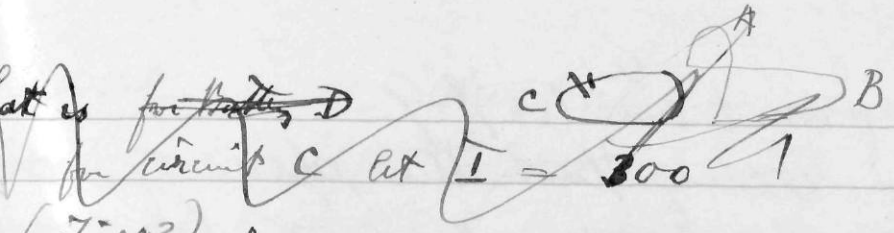
Let resistance of circuits A B C be equal; and the electromotive forces D + E be equal and opposite what relation will subsist between the currents on the ~~two~~ three circuits.

Current from D when it comes to FG splits.
Resistance of A+B to current D $= \frac{B}{2} = \frac{C}{2}$
Hence Total Resistance of 2 combined circuits for current D $= C + \frac{C}{2} = \frac{3C}{2}$ but $I' = \frac{E}{R} = \frac{E}{\frac{3C}{2}} = \frac{E}{1} \times \frac{2}{3C}$
$= \frac{2E}{3C}$ ~~Original~~ Intensity of current if A = 0 would be $I = \frac{E}{R} = \frac{E}{C}$

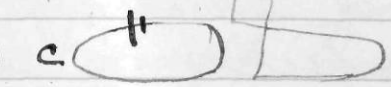
When circuit C alone is considered $I = \frac{E}{C}$
" " ABC " " $I' = \frac{2}{3} \times \frac{E}{C}$
" " CB " " $I'' = \frac{1}{2} \times \frac{E}{C}$
$\therefore I : I' : I'' :: 1 : \frac{2}{3} : \frac{1}{2}$

A. J. S.
Jan. 20. 1879

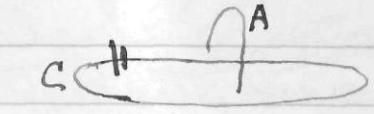
That is for battery D
for current C at 1 = 300



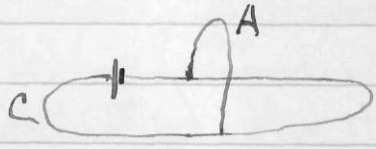
(Fig 103)

(1) 

Current = 300

(2) 

Current = 150

(3) 

Current = 200

(1) Amount of current in A = 0
B = 0
C = 300
Total = 300 E

(2) Amount of current in A = 0
B = 150
C = 150
Total = 300 E

(3) Amount of current in A = 100
B = 100
C = 100
Total = 300 E

Saturday Jan 18th 1879

See clearly that the idea of a curve of uniform motion for every sound is a most valuable scientific idea. Can it be that particles of air move with uniform motions in circles and other peculiar figures and that the apparent motion in one line is due to the apparatus employed in observing vibrations

Young has shown clearly that stretched strings do move in such ways ~~I venture to~~ (see Tyndale on Sound page 151 Fig 51) and yet I venture to say that if these stretched strings ~~which give these shorter vibrations~~ do not vibrate simply backwards & forwards in one straight line ~~were caused to~~ affect a Phonautograph or Manometric flame — they would be indicated as simply to & fro vibrations in one straight line.

Can it be that our conception ~~of sound the~~ motions of sound taking place uniformly in one

Ch. J. S.
Jan. 20. 1879

plane is a mistake — and that such an idea sprung out from the use in acoustics of apparatus that will only show a to & fro motion in one straight line.

Can the curves shown in Fig 5 (Tyndall p. 152) be curves of uniform motion? Hardly do — Some of them may be — but others are certainly not. ~~It is by no means the case that a motion to be continued must be in~~ A pendulum certainly does not move with uniform velocity, &

And yet it may do so, & it may swing in a circle — and that is the form of its vibration of uniform motion, but it vibrate in any other way its real motion is the apparent motion of a body caused to move in a circle seen from different points of view. Why should not curves of all kinds have a definite form of uniform motion which figure forms the plan view (so to speak) of all the forms

of vibration possible for that sound — which other forms can be recognized with this plan — viz as the same curve heard from different points of view.

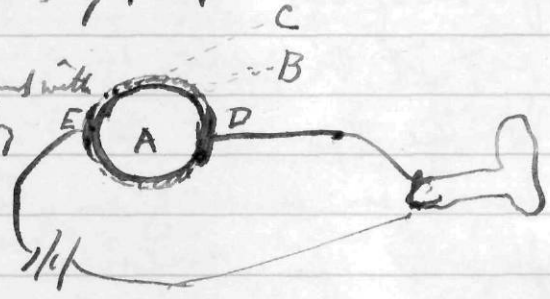
A pendulum caused to move in a circle — may be considered to be caused to vibrate simultaneously in directions at right angles to one another.

My idea

Monday Feb. 3d 1879

Have been in Boston during the past week. My "air bubble idea" grows.

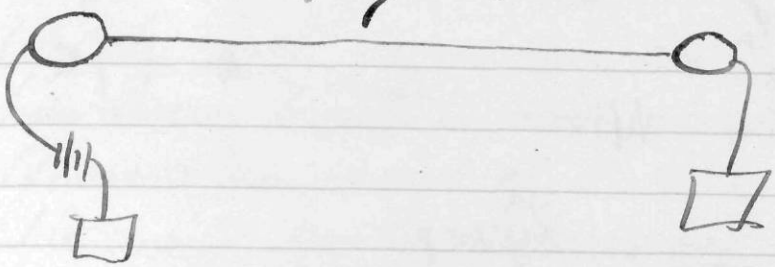
Fig 104



A a body of air enclosed in
B an elastic envelope (india-rubber) covered with
C — plumbago or other conducting material in a fine state of division
D, E wire terminals electro-plated on the opposite ends of envelope — over the plumbago.

Speak to "air-bubble" A and the sound should be heard from the telephone.

Fig 105



I see no reason why the air bubble should not act as a receiver as well as transmitter for the particles of plumbago or other material should repel one another with greater or less force during the passage the current — ~~The~~ greater the intensity of the current the more will the particles tend to separate. ~~&~~ The passage of an undulatory current should therefore ~~tend~~ tend to cause the "air bubble" ~~& expand~~ alternately to ~~contract~~ expand & contract.

Over

Fig 106

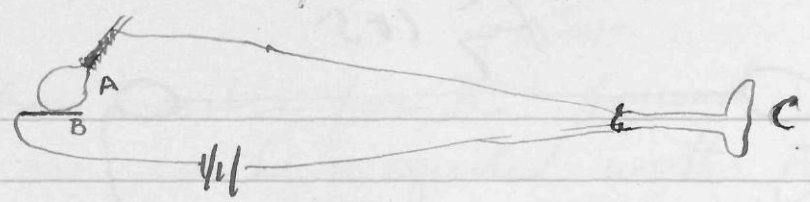


Fig 107

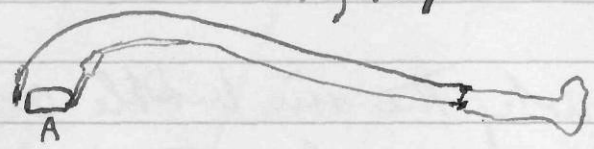
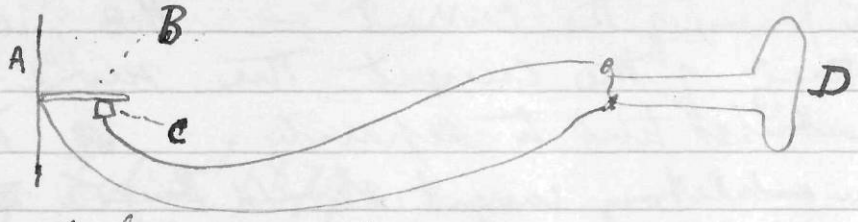


Fig 108



Thursday February 6th 1879

Last Monday evening constructed rude apparatus modled on Fig. 104 took a thin sheet of india-rubber and blew it into a small bubble or balloon tying a copper wire tightly around the neck of the balloon, so that no air could escape. I then ground up some powdered carbon and endeavored to make a conducting surface around the balloon. I was unable to cover the whole surface of the balloon

uniformly with powdered Carbon; but when the powdered Carbon was slightly moistened a sufficient amount of Carbon adhered to enable me to try the experiment shown in Fig. 106. The bdlloon A was placed against a piece of brass B, when Willie spoke to the balloon A the articulation was audible from the Telephone C which was in another room down stairs. A loud rushing sound ac-=companied the articulation which I re-=cognized as characteristic of the decom-=position of water. The experiment therefore is not by any means conclusive. When I was in Boston the other day I obtained some bismuth, Antimony, Cadmium and Aluminium, and on Tuesday evening, the 4th. inst., I made some experiments to ascertain the truth of the idea shown on page 47 Fig 45. I attached a piece of bismuth to one of the terminals of a telephone as shown at A Fig. 107 and upon completing the circuit by attaching the bismuth with the other ter-=minal [which was of brass) a very distinct click proceeded from the telephone each

time the circuit was made or broken. The same effect was produced with the other metals but not in so marked a degree as with bismuth. A piece of brass rubbed on the bismuth created quite a microphonic effect in the telephone.

Yesterday I constructed a telephone to see whether articulate effects could be produced by the frictional motion of brass upon bismuth. The arrangement is shown in Fig. 108, in which A is a telephone diaphragm, B a rod of brass, C a piece of bismuth and D a telephone of ordinary construction. When Mrs. Bell spoke against the plate A very audible effects proceeded from the telephone D.

The articulation was very imperfect but there was undoubtedly articulation there. The whole apparatus was rudely constructed and I consider the results obtained, under the circumstances as very successful.

I placed a hot wire for about half a minute between the brass and bismuth (B+C) so as to heat the points of contact, and upon removing the heated wire and

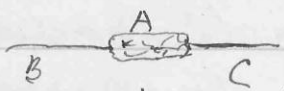
trying the telephone again, the sounds audible from D were very much louder than any obtained before. These results proved conclusively to my mind that a practically successful transmitting telephone can be made in which ~~neither~~ neither battery, magnet nor coil is employed.

Sunday March 2d 1879

Been in Boston a great part of the time since the last notes were made. I found a paper in the Philosophical Mag. by Profs Adams & Day upon the action of light in reducing the resistance of Selenium — and a full description of the process of converting Vitreous Selenium into the Crystalline form. I have accordingly followed Prof. Adams plan and have now four pieces of Crystalline Selenium about the ~~thickness & size~~. like those shown in Figs 109, 110, 111, 112, B.

94

109

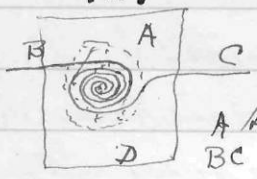


A Crystalline Selenium proper size
B C Platinum terminals

110

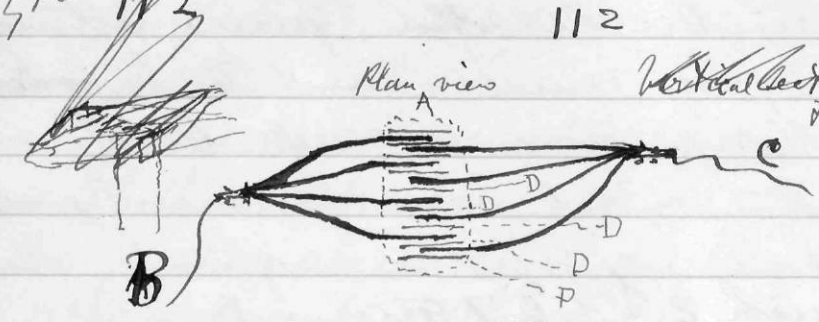
A Selen.
B & C Plat. Term

111



A Selenium
BC Double spiral of Plat. wire
D Plates of mica between which the Sel. & spirals are placed.

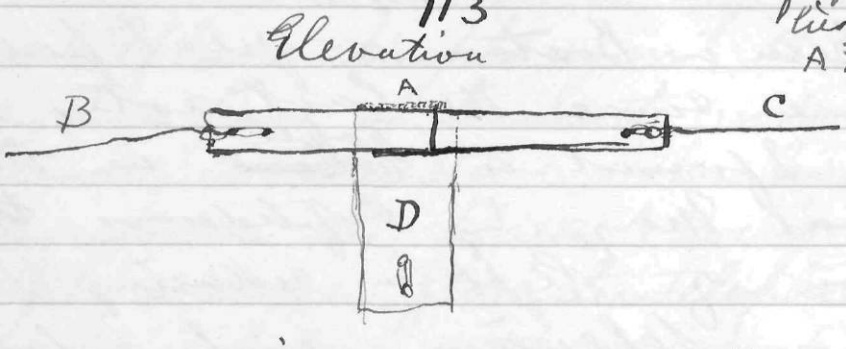
112



Vertical Section & Perspective view
Figs 112, 113, 114

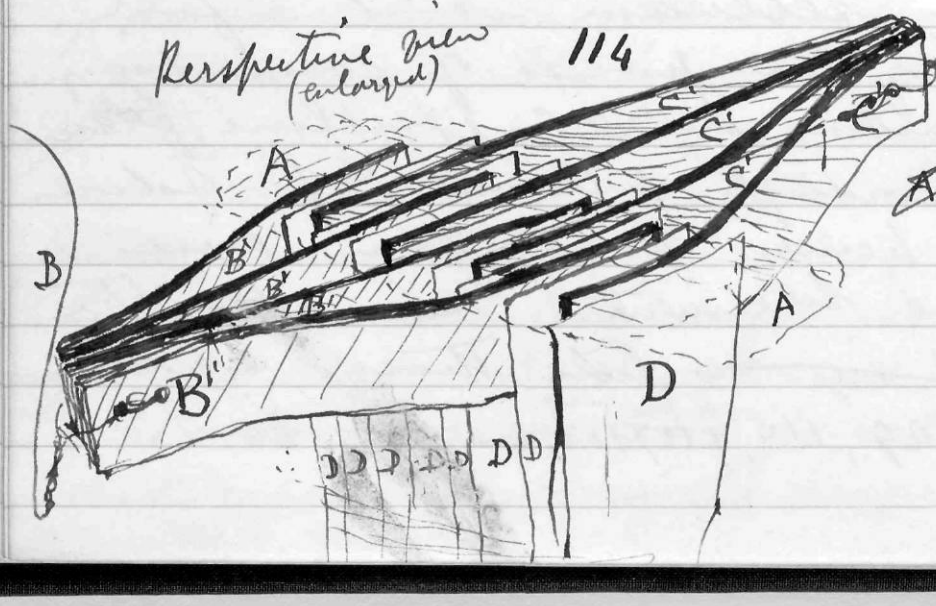
A Condenser sort of arrangement consisting of platinum leaves attached to B & C separated by leaves of mica D D & a thin layer of crystalline selenium lies on surface as at A Figs 112, 113, 114,

113



Perspective view (enlarged)

114



A A thin layer of Selenium

I took these to the Institute of Technology in Boston a few days ago to have the resistance measured. The condenser arrangement (Figs 112, 113, 114) was found to be broken — and the pieces shown in Figs 109, 110, 111, were found to exceed 1,000,000 ohms. — As this was the limit of the bridge arrangement at the Institute of Technology — we had to give up the attempt.

At Williams workshop in Boston a day or two afterwards I made another experiment using a combination of all the rheostats he had in his shop and using his galvanometer — which however was not nearly so delicate as a reflecting galvanometer. In the first place the needle was not astatic and in the second place the readings were magnified by means of a long needle of aluminium instead of a beam of light. Under these circumstances the readings were very uncertain when such high resistances were to be measured.

At Williams The piece shown in Fig 109

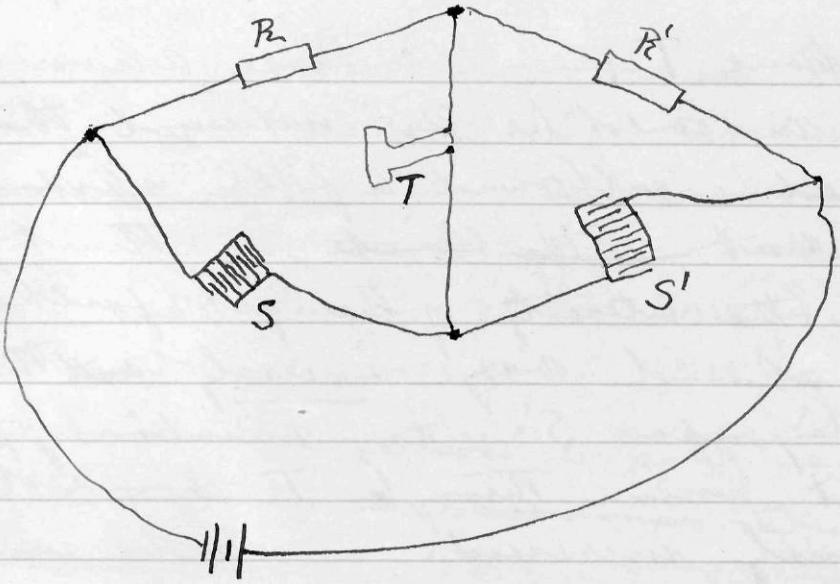
we could not measure — but those shown in Fig 110 & 111 gave indications, ~~that should that~~ showing that their resistances were somewhat as follows: —

(1.) Selenium in Fig 110 = 25,000,000 Ohms
(2) — — — Fig 111 = 11,500,000 Ohms

Of course these resistances are only approximate ~~on account of the~~ ~~because (1) the~~ ~~small (3 cells Gravity) (2)~~ on account of (1) the small electro-motive force employed (2) the inertia of the needle used and (3) the impossibility of magnifying the indications without re-constructing the apparatus.

It is evident that the resistance of Selenium must be measured in megohms instead of ohms — and that some sort of bridge arrangement will be necessary if we wish to utilize light. Why not receive light upon a receiving apparatus somewhat as follows: (See Fig 115)

Fig 115



R & R' Known resistances

S & S' Selenium resistances arranged as shown in detail in Figs 112, 113, 114.

T — Telephone.

Process of using arrangement. (1) Let S & S' be under like conditions of light or darkness. For the telephone substitute galvanometer and vary the resistances R & R' until no current appears through galvanometer — that is arrange matters so that

$$\frac{R}{R'} = \frac{S}{S'}$$

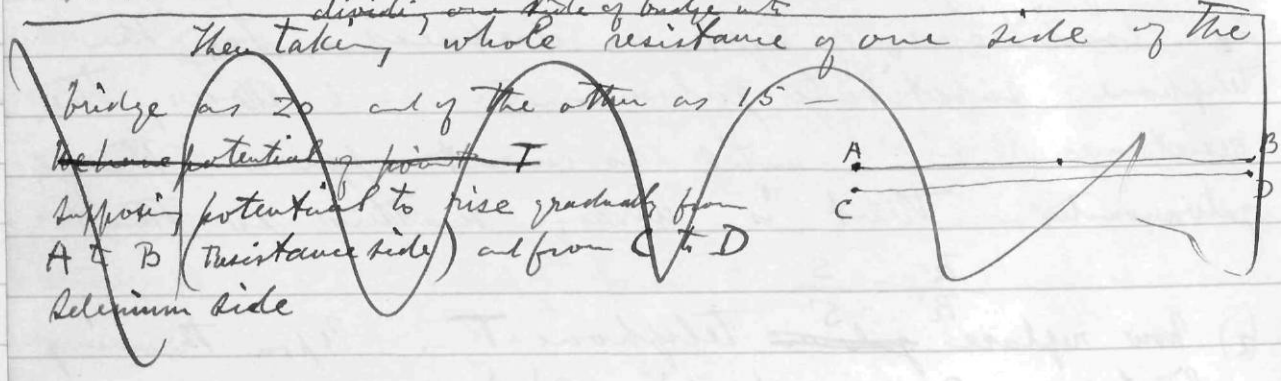
(2) Now replace ~~galvan~~ telephone T. Upon throwing light upon S and keeping S' in shadow a current should pass through T. Keep S' in permanent darkness & vary the intensity of the light thrown upon S & sounds should be audible

from telephone T.

(3) If matters could be so arranged that light could be allowed to fall upon both S & S' ~~& the light~~ so that ~~variations~~ the intensity of the light falling upon S should vary inversely with the light falling upon S' the variations of the current passing through T would be enormously increased. ~~When both~~

~~When~~ When S & S' are equally ~~illuminated & opposed~~ darkened

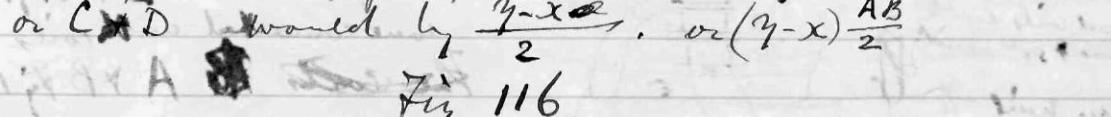
Let S = 10 Megohms and S' = 10 Megohms
Also let R = 10,000 ohms & R' = 10,000 ohms
No current passes through Telephone.
Now let light fall upon S and let its resistance sink down to 5 Megohms.
dividing one side of bridge into
Then taking whole resistance of one side of the bridge as 20 & of the other as 15 —



~~Before~~ potential of point T
supposing potential to rise gradually from A & B (Resistance side) & from C & D Selenium side

Let A B (Fig 116) represent one side of bridge (Resistance side) and C D the other side. The potential points A & C and the points B & D have the same ~~potential~~ ~~difference~~ Supposing the resistances (R & R' Fig 115) to be spread evenly along the whole line A B (Fig 116) & the resistances S & S' (Fig 115) along the line C D (Fig 116) then if we take a point half way along one line and unite it with a point half way along the other line the two points will be found to have the same potential and no current will flow. Taking the potential of A or C as (x) and that of B or D as (y) we would find that the ~~point~~ potential of a point midway between A & B or C & D would be $\frac{y-x}{2}$. or $(y-x)\frac{AB}{2}$

Fig 116



(1) Call Light resistance of S to S' negligible. Potential of T shown at $AB = \frac{AB}{2}$ Potential of T' equal $\frac{CD}{3}$, Difference of potentials of T & T' = difference between $\frac{y-x}{2}$ and $\frac{y-x}{3}$ If resistance of rest of circuit be so small compared to resist. of AB & C'D as to be ignored $y-x$ will equal the whole electro-motive force and the potentials of points T & T' will be respectively $\frac{E}{2}$ & $\frac{E}{3}$ and $\left(\frac{E}{2}-\frac{E}{3}\right)$ or the difference of potential between T & T' $= \frac{E}{6}$ or $\frac{1}{6}$ th of the whole electro-motive force of the circuit.

Saturday July 19th 1879 — Cambridge —

"Phon-Electrometer" or "Phono-galvanometer"

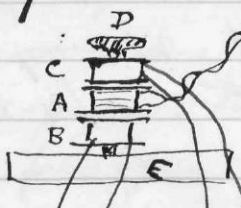
Arrangement shown in Fig 116 ~~[illegible]~~ were completed today and tried tonight.

Fig 116

A Rheotome
B Four cells (Leclanché)

Arrangement here shown placed in greenhouse No 1.

Fig 117

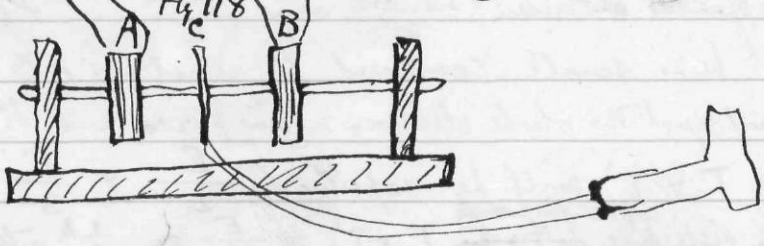


A Coil about 50 ohms in circ. with Rheotome.
B } Equal coils each
C } about 50 ohms resist.
D. Copper weight to hold arrangement on base-board E
Coils A B & C were ordinary hand-telephone coils.

Arrangement shown in Fig 117 in new workshop. Coils B & C Fig 117 were connected with coils ~~[illegible]~~ A & B Fig 118

Rheostat

Fig 118



To show the arrangement more clearly I give Figs 116, 117, 118 in one complete view in Fig 119

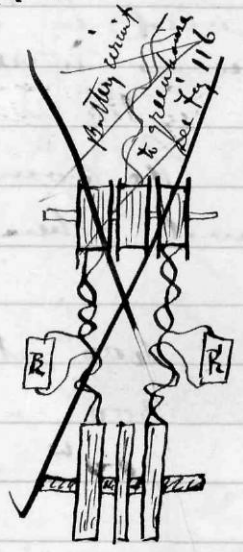
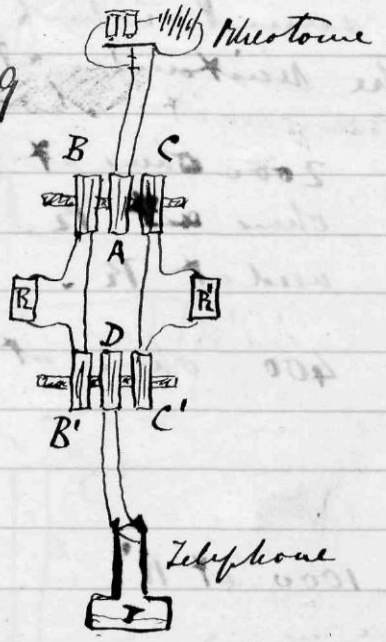


Fig 119



The coils BAC, B'DC' the Rheostats R,R', and the Telephone were placed this evening in the new workshop or laboratory and the Rheotome was placed in greenhouse No 1.

1. When the coil D was mid-way between B' & C' no noise was heard from the telephone but when it was placed nearer one of the coils B' C' than the other a sound was heard of similar pitch that produced by the Rheotome.

2. The coil D was placed in its position of silence and then 1000 ohms inserted at R'. Result loud sound audible from telephone. Resistance was then gradually inserted at R. As the resistance of R was increased the sound from the telephone decreased and when 1000 ohms had been inserted at R no sound

was audible from the telephone. Further increase of resistance at R again produced a sound which increased in intensity as the resistance at R was increased.

3. 2000 ohms at R'. No sound when 2000 ohms at R. Sound when 1000 or 3000 used at R.

4. 400 ohms at R'. 400 at R No sound
" " " " 300 " " Sound
" " " " 700 " " Sound

5. 1000 at R' — 1000 at R — silence
" " " 600 " " slight sound
" " " 400 " " much louder sound
" " " 700 " " very loud sound
" " " 800 — silence
" " " 900 — silence
" " " 1000 — silence
" " " 1100 slight sound
" " " 1200 louder
" " " 1400 louder
" " " 2000 much louder
" " " 3000 very loud.

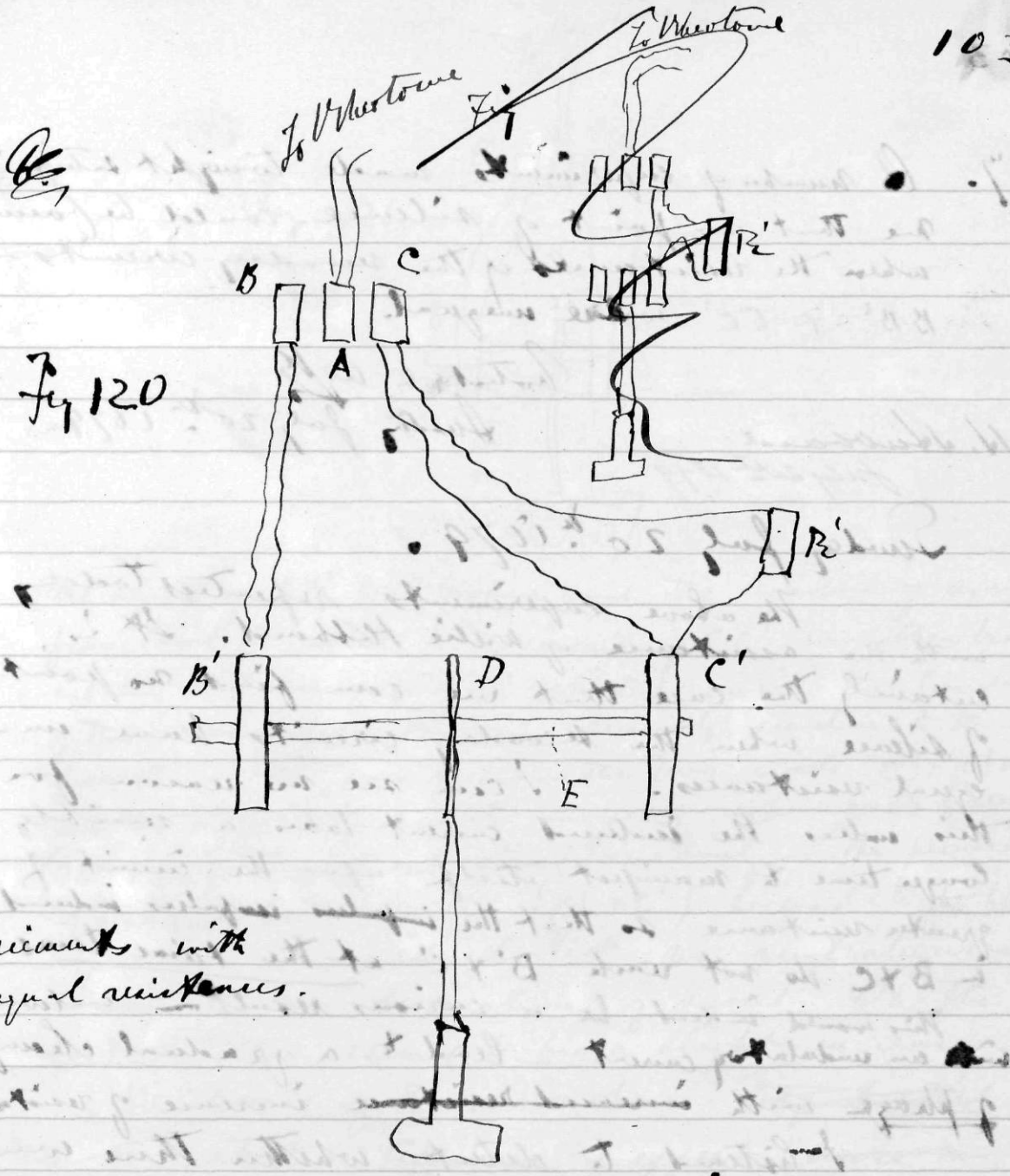


Fig 120

6. Experiments with unequal resistances.

6. Resistance of 1000 ohms inserted at R' and the coil D was moved between B' & C' in the expectation that a point of neutralization about E would be reached. No point of silence was obtained but the minimum sound audible was somewhere about E.

7. A number of experiments made tonight satisfies me that no point of silence could be found when the resistances of the secondary circuits — BB' & CC' were unequal.

Noted by AGB
Sunday July 20th 1879

W. H. Hubbard
July 20th 1879

Sunday July 20th 1879.

The above experiments repeated today with the assistance of Willie Hubbard. It is certainly the case that we can find no point of silence when the secondary circuits have unequal resistances. I can see no reason for this unless the induced current takes a sensibly longer time to manifest itself upon the circuit of greater resistance so that the impulses induced in B & C do not reach B' & C' at the same time. This would indeed be a curious result — and would make an undulatory current — lead & a gradual change of phase with increased resistance increase of resistance.

I listened to detect whether there was a difference of quality resulting from increased resistance — and it really seems as if there is.

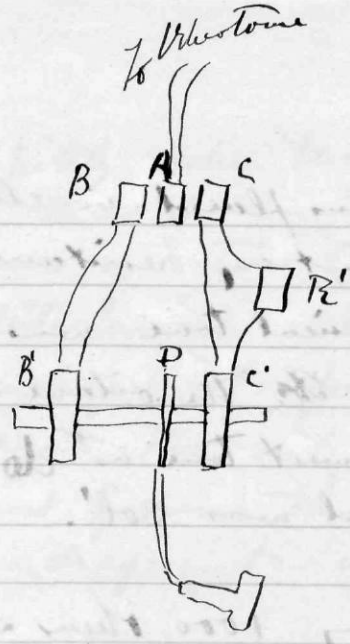


Fig. 121

1. The circuit of BB' was broken and the loudness of sound from coil C' noted. The circuit of CC' was then broken and the distance of coil B' shifted until the loudness of the sound from B' was sensibly similar to that from C'. The sounds from the two coils B' & C' were sensibly different in quality — and when both circuits (BB' & CC') were closed simultaneously — the peculiarities of tone from both coils (B' & C') seemed to be blended together — I could detect no neutralization — no even diminution of sound. On the contrary there seemed to be a slight increase.

Resistance of R' 1000 ohms. ~~The effect did~~

2. ~~more marked~~ Difference of effect ~~more~~ between coils B' & C' more marked as resistance R' was increased.

3. When coil D was arranged as in (1) the sound from telephone was louder when both coils were used than when one. But when both coils were used the position of D was found to be the position of minimum sound.

3. Coil C' was placed in close proximity to D — without any resistance at R' — a low musical tone was loudly perceived accompanied by the octave of its fifth. Taking the lowest tone as do the predominant upper partial was sol'.

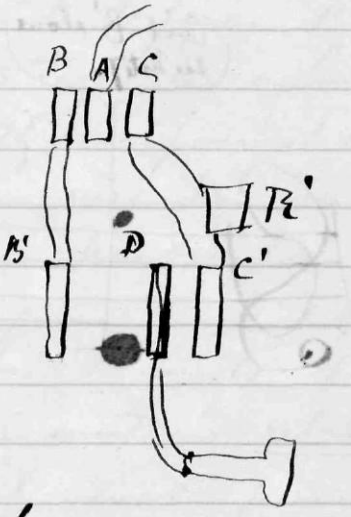
6. Upon placing 1000 ohms at R' — the character of the tone audible from the telephone was changed. The loudness of the sound was immensely diminished — and the quality was entirely changed. I was uncertain whether either do or sol' were present. I think "do" was but so feeble that it was masked by the predominance of high upper partials. I could distinctly recognize (mi 2) and I thought I distinguished either the octave or the double-octave of the original do.

5. When the 1000 ohms resistance were inserted & cut out again a number of times in succession — it seemed as if the pitch of the lowest second audible changed also.. Both Willie Hubbard & I thought it sounded

slightly lower in pitch when the resistance was in (& of course fainter) than when it was out.
The great difference of intensity however made it difficult to determine whether the fundamental sound became changed in pitch — and I am loath to believe that it did.

I am convinced however that the predominant upper partials were different when the resistance was in and out.

6. Similar experiments made with coil B' gave similar results.



7. Coil B' alone gave "do" and "sol" Fig 22
When B' was removed further from D both ("do & sol") were still audible but decreasing in loudness as the distance between B' & D was increased.

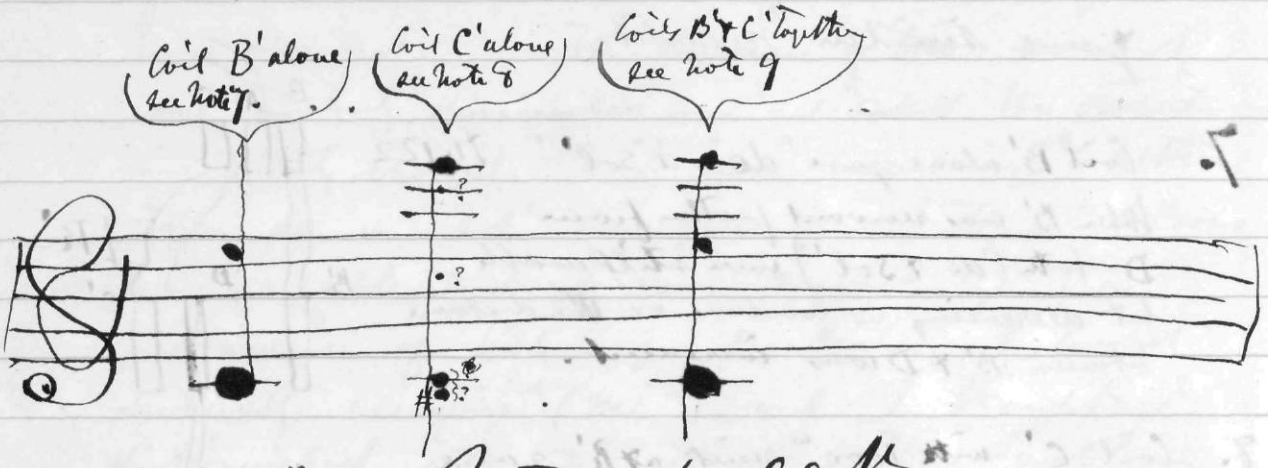
8. Coil C' with 1000$^{\omega}$ resist at R' gave
~~[illegible]~~
Could not distinguish sol' but perceived distinctly "mi^2" — It seemed also as if "do' or do^2" was present. The fundamental do is present at all was scarcely audible. The ~~[illegible]~~ made up of upper partials having undue prominence

9. While coil C' with 1000 ohms was being used. Coil B' was also connected and at once it seemed to complete the chord — filling in with great force the fundamental do. I could clearly distinguish in addition to "do" — the characteristic upper partials of the two coils B' C' namely sol' & mi^2.

10 I cannot give the absolute pitch of the Vibrators or of the sounds heard. But calling "do" C

C.  I can give the ~~other~~ other tones relating to it.

In the last experiments noted on Nos. 7, 8, & 9 and illustrated in Fig 122 results were as follows



Notes ag'n
Sunday July 20th 1879.

W. H. H.
July 20th 1879.

Monday July 21st 1879 — Cambridge —

Repeated the experiments mentioned on pages 100 to 108 with the assistance of Mr. Olsen. We agree in the following results. Using the coils

1. Effect of distance.

The coil D (Fig 121) was placed against coil B' — ~~the circuit of C~~ C' being broken C' not being used. The effect produced by gradually removing coil D from B' was noted. When they were together a loud sound was audible evidently compound in its nature. We could recognize the loud fundamental and two upper partials. ~~The~~ The removal of D from B' did not affect the pitch of any of these sounds but seemed to produce a change in their relative intensities. The fundamental lost power much more rapidly than the upper partials and a point was reached where the fundamental could no longer be distinguished while the upper tones were still markedly audible. Upon still further removing D from B' — ~~the sound~~ a point was reached where the curves of the two partials

~~be~~came inaudible and the higher was left by itself. Still further removal of D from B' ~~ca~~ caused the extinction of the higher sound and nothing was audible. Upon reversing the process ~~and ca~~ causing D to approach B' the tones re-appeared in the order of their pitch: first the high tone ~~and~~ next the low tone and finally the fundamental.

2. Effect of increasing resistance.

The coils D & B' were next placed close together and resistance inserted at R see Fig 119 page 101. ~~The fundamental & upper partials ~~ referred to above~~ Similar effects were noted as for increasing distance. The pitch of the tones audible was not affected but the relative intensities seemed to change. As the resistance increased the fundamental was gradually lost, ~~& next the "lower" partial. With~~ and the loudness of the lower ~~partial~~ of the two upper tones was markedly affected — but with the highest resistances used (7000 ohms) — both tones were still audible. In addition to this change the sound acquired a peculiar metallic quality of an indescribable nature as the resistance was increased. It seemed to me as if a number of

extremely high tones from the brought out forming a sort of noise accompanying the musical elements distinguishable — but neither Mr. Osborn nor I were able to analyze our sensations otherwise than to state roughly that some change of quality was produced by increasing resistance — different from the change produced by increasing distance.

3. We were able to compare the two effects directly by using both coils B' and C' Fig 122. No resistance was used with B' and 1000 ohms was introduced at R'. The coil D was so arranged that the loudness of the sound from B' was nearly similar to that from C'. By first one coil B' and then the other C' we were able to observe a great difference in the quality of the sounds. As Mr. Osborn happily expressed it — the sound from C' was "harsh and metallic" — while that from B' was "velvety"

4. When both the coils B' & C' were simultaneously used — the resulting sound was not diminished in intensity — (to my ear it was slightly louder than when one was used — & Mr. Osborn's ear no difference was observable) the "velvety" & "harsh" effects seemed to be blended together. Notes by A.G.B. July 21st 1879

M.G.B. July 21st 1879.

Tuesday July 22! 1879

Experiments on preceding pages repeated and verified and certain new points noted.

Particulars of coils & used.

A, B C ordinary hand-telephone-coils about 50Ω resist. fine wire - I think No 38.

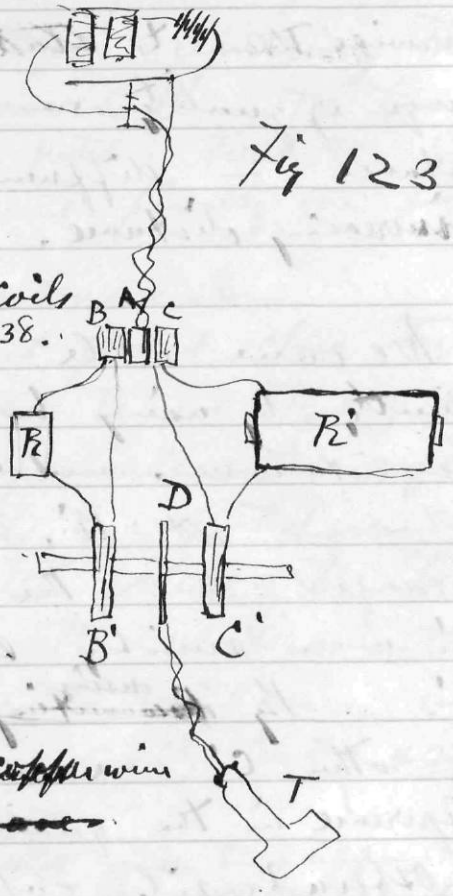


Fig 123

B' & C' Coils of No 23 copper wire insulated with silk. ~~Each coil is~~

Extern. diameter — 4 inches
internal diam. — 3/4 inch
Thickness — inch
Calculated number of convolutions — — —
Resistance —

Coil D. A flat spiral of No 30 ~~copper~~ wire silk-covered. ~~One coil only~~

extern. diam. 4 inches
intern. diam. 3/4 inch
thickness — a single layer of wire ~~glued~~ upon a paper disk,
resistance — —

T. ordinary ~~hard~~ vulcanite hand-telephone resist. about 50 ohms.

R. Rheostat.

R'. Large helix of thick copper wire, — particulars as follows

R' Particulars of ——
1 Length
2 Extern. diam.
3 intern. diam
4 Estimat. number of convolutions
5 Resistance
6 Thickness of wire ——

Core — dimensions of .
1 Length.
2 Diameter.
3 Weight..

New Experiments

1. The attempt was made to balance the induction of C' when R' was in circuit by inserting resistance at R.

D was first placed in its position of silence when no resistance was in either of the secondary circuits. R' was then inserted. A sound was heard from the telephone in the tertiary circuit. Resistance was gradually inserted at R. The quality of the resultant sound was not affected — but no appearance of neutralization resulted.

2. It was then attempted to balance the effect of of R' by moving the coil B' instead of inserting resistance

at R. A very slight movement of B' from D occasioned a marked diminution of the sound and it was noticed that at one point the fundamental tone disappeared the highest upper partial persisted.

A hairsbreadth motion of the coil B' on either side of its position of neutralization caused the reappearance of the fundamental. The effect of the persistence of the highest partial and the alternate appearance & disappearance of the fundamental as B' was moved backwards & forwards was most striking.

3. B' was left in its position of neutralization and the effect noted of removing the core of R'. The high upper partial was heard without the fundamental. But the removal of the core of R' caused the re-appearance of the fundamental.

4. Upon then moving the coil B' a little nearer to D it was found that at one point the high upper partial disappeared while the fundamental persisted. The motion of the coil B' to either side of this point caused the

reappearance of the high tone — but the fundamental was not ~~neutralized~~ seemingly affected.

5. We found it impossible to neutralize either the fundamental or the high tone by inserting resistance at R — but an effect was produced upon the quality of the sound.

Calling the fundamental (d) the high upper partial seemed to me to be (m^2). The insertion of 20 ohms resistance at R seemed to me to cause the re-inforcement of a tone about (S'). Mr Osborn — while agreeing with me in my observations felt himself unable to decide upon the relative pitches of the fundamental & re-inforced partials — and proposes that we investigate the subject by means the absolute pitches of the partials by means of Helmholtz' Resonators.

6 I was able to distinguish the partial (S') very faintly throughout our experiments as an invariable accompaniment of the fundamental. When the core of R' was inserted and the coil B' moved on either side of the position of neutralization — the high tone (m^2) persisted & the fundamental (d) and partial (S') alternately appeared & disappeared ~~alternately~~ together.

Ned so when the core of B' was removed. The tones (d) and (S') persisted together and (m^2) appeared & disappeared as the coil B' was moved ~~backwards and for~~ about its position of neutralization.

7. Experiments were also made with an induction coil in place of B' shown in Fig 123.

The coils C C' were placed in circuit with the secondary wires of the induction coil I (Fig 124) and the coil B' was placed in the position of neutralization.

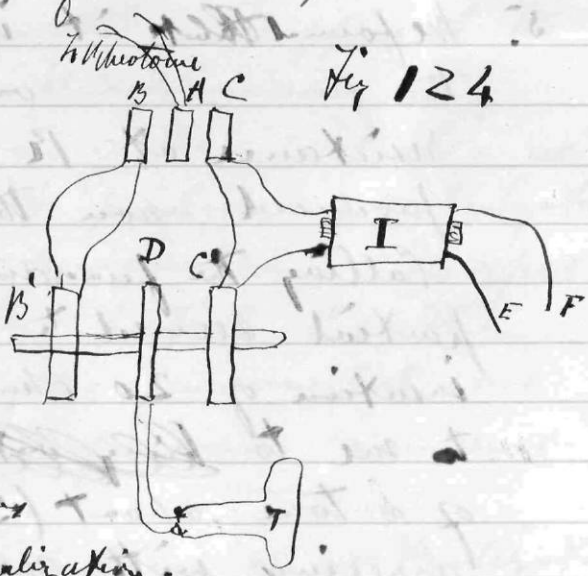


Fig 124

The fundamental disappeared & the high upper partial alone was heard. Upon ~~inserting a single~~ connecting the poles of a single Leclanché cell ~~of~~ with the ~~terminals of the~~ primary terminals E F the fundamental ~~was~~ at once became manifest.

No difference of effect was noticed when the battery upon the primary circuit of I was reversed.

8. ~~Place in next column~~ The mere contact of E & F without any battery on the circuit produced the effect & in quite as marked a degree.

9. The removal of the bundle of iron wires forming the core of I produced the same effect without any closure of the primary circuit.

10. ~~When the~~ After the core of I had been removed the contact of E & F produced a very slight effect. The intensity of the fundamental was ~~not~~ slightly increased ~~by~~ ~~by so doing~~

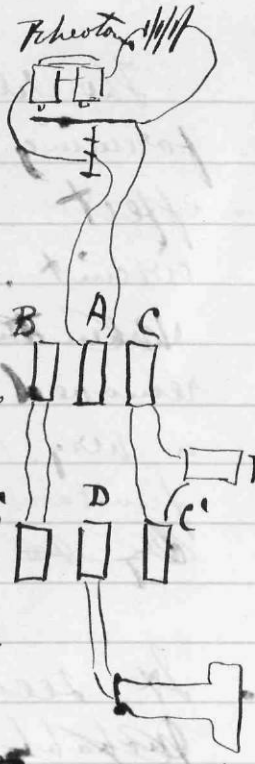
11. It seems to me that the effects are ~~probably caused~~ in some way due to the multiplied induction. Point to be worked up. The number of electrical impulses in a secondary circuit are always double the number in the primary. A current is induced in one direction when the primary current stops. & in the other direction when it stops. ~~Then~~ Consider effect upon coils of one arrangement (Fig 124) Intermittent voltaic current traverses A. Twice the number of impulses per second appears upon circuit B B', and four times that number per second in the telephone or tertiary circuit.

I shall try to show my meaning by a graphical

Illustration.

Graphical representation of current

Rheotome



(1) Zero — Zero

Circuit by coil A

(2) Zero — Zero B'

Circuit B B' and C C'

(3) Zero — Zero

(4) Zero — Zero

Currents induced in D by coil B'

Currents induced in D by coil C'

(5) Zero — Zero

Resultant effect in D neutralization.

If however the [illegible] electrical impulses do not arrive in coil C' at the same time as in coil B' on account of resistance R' — then resultant effect in D might be as follows.

(6) Zero — Zero

If the displacement of the current in coil C' were to result as to cause a positive impulse from C' to coincide with a positive impulse from B' the following would be something like the resultant effect.

(7) Zero — Zero

If this last effect is produced we ccccc see that the number of strong positive impulses ~~corresponds~~ in the tertiary circuit corresponds to the number of vibrations of the rheotome and thus might produce the fundamental while the ~~smaller~~ merely irregular impulses would produce upper partials.

Queries. What is the duration of one of the secondary impulses in B B' or C C' ?

The distance ~~apart of the~~ between the direct reversed impulses in the tertiary circuit (see line 4) corresponds to the duration of a single impulse in the secondary circuit.

I only know that the duration of such an impulse is almost infinitesimally short. Hence an almost infinitesimal delay in the passage of an impulse through the resistance R' would bring about the result shown in lines 6 and 7. Perhaps we may yet be able to calculate the speed of an electrical impulse by the peculiar tones produced in a telephone arranged somewhat as in these experiments. All the above noted experiments & calculations & deductions from page 112 were made today Tuesday July 22d 1879 A.G.B.

M.G.B. July 22nd 1879.